NATURE

No. 4163 SATURDAY, AUGUST 13, 1949 Vol. 164

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Telegrams: Phusis Lesquare London
Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

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FUNCTIONS OF THE PRESS

THE report of the Royal Commission on the Press, 1947–49*, set up as the outcome of a division in the House of Commons on October 29, 1946, contains little that was not forecast in the course of the debate preceding that division. The wilder charges against the British Press are plainly refuted. "There is nothing approaching monopoly in the Press as a whole or, with the single exception of the London financial daily, in any class of newspaper; nor is there in those classes of periodical which the Commission examined." Likewise, the Commission concludes that the present degree of concentration of ownership in the newspaper Press as a whole or in any important class of it is not so great as to prejudice the free expression of opinion or the accurate presentation of news, or to be contrary to the best interests of the public.

Nevertheless, the Commission is severely critical of the Press, and although it exonerates the British Press from subordination to personal interest and outside pressure and says plainly that the causes of the shortcomings emphasized in the report do not lie in any particular form of ownership, the Commission's findings justify complacency neither on the part of the Press nor of the public—nor, it might be added, on the part of the Government which appointed the Commission. The Commission finds, indeed, that the British Press is inferior to none in the world, that it is free from corruption, completely independent of outside financial interests and that there are no monopolistic tendencies. Most of the quality papers meet the Commission's first requirement that, while the selection of news may be affected by a newspaper's political and other opinions, the news it reports should be reported truthfully and without excessive bias. All the popular papers and some of the quality papers fail to meet this requirement, either through excessive partisanship or through distortion in the interest of news value, or both.

The Commission's second requirement is that the number and variety of newspapers should be such that the Press as a whole gives an opportunity for all important points of view to be presented effectively in terms of the varying standards of taste, education and political opinion. The Commission considers that the Press does provide adequately for a sufficient variety of political opinion but not for a sufficient variety of intellectual levels. The gap between the best of the quality papers and the general run of the popular Press is too wide, and the number of papers of an intermediate type is too small. There is a lack of newspapers which are more serious and better balanced than the popular papers but more varied and easier to read than the quality.

Fundamentally this position is due, as the report emphasizes, to the increasing complexity of public affairs and the growth of the reading public creating a need for public instruction on an entirely new scale without producing, as yet, either the corresponding demand or the corresponding supply. The Commission

* Royal Commission on the Press, 1947–1949. Report. (Cmd. 7700.) Pp. v+363. (London: H.M. Stationery Office, 1949.) 6s. net.

recognizes, indeed, that a newspaper cannot raise its standard far above that of its public and may profit by lowering its standard to gain an advantage over a competitor. This tendency is not always resisted as firmly as the public interest requires. When the Commission continues: "The Press does not do all it might to encourage its public to accept or demand material of high quality", the man of science might be tempted to add that many newspapers are not appreciative of efforts to raise the standard of reporting of scientific and technical matters.

The Press has nevertheless considerable achievements to its credit. "It provides cheaply and efficiently a mass of information and entertainment for which there is a wide demand. It acknowledges high standards of public responsibility and service. It is jealous of its own independence and reputation and many of those employed in it have a sense of vocation."

For such reasons the Commission wisely rejects the idea of any major changes in the ownership and control of the industry, including State control. "Free enterprise is a prerequisite of a free Press, and free enterprise in the case of newspapers of any considerable circulation will generally mean commercially profitable enterprise." It seeks instead the means of maintaining the free expression of opinion and the greatest practicable accuracy in the presentation of news, and, generally, a proper relationship between the Press and society, primarily in the Press itself. For this purpose it recommends that the Press itself should establish a General Council of the Press, with a lay representation of about twenty per cent, including the chairman, nominated jointly by the Lord Chief Justice and the Lord President of the Court of Session, with the object of safeguarding the freedom of the Press, and encouraging the growth of a sense of public responsibility and public service among all engaged in the profession of journalism.

This proposal represents such a departure from the usual form of professional body responsible for the maintenance of high professional standards that it is not surprising that it has had rather a mixed reception, nor does it appear very clear from the report what such a Council could achieve. In the debate in the House of Commons on July 28, Mr. Herbert Morrison said that the Government hoped to see the Commission's recommendations on this issue voluntarily put into effect by the Press itself. In the event of this not being done the Government would then look closely into the matter. In replying, Mr. Oliver Stanley preferred to leave the question entirely in the hands of the Press and doubted if a statutory body set up in defiance of the wishes of the Press would have any chance of success.

The Commission attributes some of the shortcomings of the Press very largely to an inadequate standard of education in the profession of journalism. There will be some men of science who will endorse the opinion of the Commission that the standards of education prevailing generally in the profession are not high enough to enable it to deal adequately with the increasing complexity of the events and the background which the modern journalist must interpret and report. The improvement of professional standards is essentially a matter for the profession of journalism itself, whether or not the suggested Council can play a useful part. So far, however, as public opinion affects Press standards, that is a matter of education in which the raising of the school-leaving age may ultimately have a beneficial effect. No doubt, educational policy as pursued by the Minister of Education may also contribute to that end; but there is another sphere in which Government policy can have an even more direct influence.

In a chapter on external influences, the Commission examined evidence regarding the effect of Government Information Services without finding any support for the view that any harmful influence was yet being exerted on the Press by such services, although there would be danger if newspapers came to rely on taking all or most of their news unquestioningly from a Government department. The outstanding impression left by the whole report, however, is that the main factor responsible for the shortcomings of the Press during the past ten years is the shortage of newsprint. "The most striking fact about the Press at the present moment, and from the point of view of our inquiry one of the most significant, is the persistence for the last ten years of an acute shortage of newsprint. . . . The reduction to four or five pages of newspapers which before the war averaged over 20 means that much important material cannot be published and that what is published must be highly compressed. Much news must be 'suppressed' for this reason alone and severe compression makes inaccuracy and distortion more difficult to avoid. The likelihood that the Press will be the subject of complaints is increased."

While it does not overstress the importance of this factor, admitting that an increased supply of newsprint would merely remove one of the impediments in the way of improving the Press, the Commission returns repeatedly to this point in its report, and it brings out plainly that the present position is mainly a Government responsibility. In reference to the reduction in supplies of newsprint in July 1947, the Commission endorses the view that this decision of the Government endangered the primary liberty of free discussion which depends on access to adequate information. The continued shortage of newsprint deprives the public of news and information and the stimulus of a free and copious discussion of all topics of current interest. The British public is becoming ill-informed, and, having regard to British responsibilities abroad and British problems at home, it should be a major political and social responsibility of the Government to put the Press in a position to discharge adequately its full normal functions.

In stressing, therefore, the importance of securing at the earliest possible date an adequate supply of newsprint, the Commission points out that it is also important that newsprint should be made available for the establishment of new papers. It expresses no opinion as to what priority should be given to the import of newsprint or pulp in relation to other scarce materials, or how the available newsprint should be allocated, but it would welcome any

increase in supplies which may be compatible with the economic position of the country. Nor could it well be made plainer that a main responsibility for present deficiencies in the British Press must rest with the Government; and in the debate on July 28 Mr. Morrison dealt in only brief and vague terms with the question of newsprint supplies.

Much more might, indeed, be said on that point if a Royal Commission could scarcely have said it. The hasty and ill-judged ban on the prohibition of publication of technical periodicals in the spring of 1947 may not have been prompted by a desire to suppress or hinder informed criticism; nevertheless there has been displayed too often impatience or resentment of such criticism or comment to dispel the impression that the Government has not been sorry to have any excuse for putting difficulties in the way of public discussion, and there has been no action which suggests that the Government is alive, as the Royal Commission is, to the danger in the world to-day of the British public being ill-informed on world or home affairs. Moreover, besides the vital part which the Press has to play in the formation of sound judgments on public affairs, the increasing concentration of power in the hands of the Government enhances the importance of the Press as a watchdog over personal liberties. The free expression of ideas must not be imperilled for the sake of saving a few dollars by the reduction in pulp supplies.

It is imperative in a world where totalitarianism is rife in many different guises that the public should be on guard against any encroachment of the traditional freedom of the British Press, whether it be by the development of powerful private monopolies or by unwarranted State interference. In this respect the responsibility for vigilance probably lies more with the general public than with those actively engaged in the publishing of news. The Commission has already criticized the level of taste shown by the public in its appreciation of newspapers, and thus the Press cannot be completely blamed for pandering to such taste. In the same way, though the Press should be the first champions of civil liberties, it is the people themselves who must safeguard their own freedom of the written word.

THE VILLAGE DORMITORY

The Muria and their *Ghotul*

By Verrier Elwin. Pp. xxix+730+151 plates. (London: Oxford University Press, 1947.) 42*s*. net.

DR. VERRIER ELWIN'S very substantial volume "does not profess to be a study of Muria culture as a whole", but it is, in fact, an exhaustive monograph on the Muria Gond tribe of Bastar State in east central India, approached, and very advantageously indeed, through the medium of one of their most individual institutions, that of the *ghotul*. The *ghotul* is the young people's dormitory; but its use is not restricted, as in so many tribes (for this institution is very widespread), to males only. Among the Muria, children of both sexes start sleeping in the *ghotul* at an early age, and they are not segregated there. There seem to be two types of *ghotul*, one in which each individual has his or her allotted partner to whom fidelity is due during the continuance of life in the *ghotul*, which lasts until marriage; in the other type, permanent or semi-permanent attachment to an individual is banned, and though some of the officers of the institution may have quasi-permanent partners, the sleeping partners of the rank and file are decided for them and varied systematically every few days. Elwin regards this type as a modern variation from the one in which partnerships are expected to be continuing, but it seems possible to the reviewer that it is more likely to be a partial reversion to the less regulated promiscuity of an older pattern which had been changed gradually into the type with permanent partnerships.

In any event, the life of the inmates is described by Elwin with very great detail; he pictures an almost idyllic existence from which jealousy and fear and passion are banished, in which selfishness is exorcised and prostitution unknown, and where the young men and damsels of the tribe ('maidens' would scarcely be the appropriate word) live together in an atmosphere of communal and cousinly, though far from platonic, love. It is true that there are passages which suggest that the old Adam shows itself from time to time; but on the whole the author makes a really good case for the overriding beneficent value of the institution to the Muria tribe, and the essentially moral influence of the *ghotul* in Muria life.

Seeing that it is the most important of tribal institutions, the *ghotul* is properly used as a means of approach to Muria culture generally. The seventeen chapters in Part 2 of the book are nominally all concerned with some aspect of the *ghotul*, but include a very detailed account of songs, dances, games and recreations, and a chapter on marriage, and one on dreams, which theoretically are not experienced at all when sleeping in a *ghotul*. Part 1 contains eight chapters on the culture of the Muria in general, an arrangement which inevitably involves a certain amount of repetition. They deal with the general pattern of Muria life. Starting with the geographical environment and the historical background, some account is given of the Murias' relations with the surrounding tribes, and the remainder of Part 1 deals with the livelihood, clan system, *rites de passage* and religion of the Murias, and the legend of the god, or culture-hero, Lingo. Among other points are the absence of any obvious initiation ceremony, the tattooing, which, as among the Assam hill-tribes, is done by women, the erection of monoliths in honour of the dead, and the association of the dead with the fertility of the soil. These are features for which there are many parallels; but the Anga is a godling peculiar to the Muria. He is a sort of recumbent idol, made from a tree and informed with the lives of the old men who, having made him, soon die. He has to be carried on a sort of frame by four men, and when so carried acts as a sort of oracle controlling the course and behaviour of the bearers to indicate his will. The corpse of a dead man carried on a bier is similarly used as a means of divination.

Part 2 starts with a long chapter (fifty-six pages) on the origin of the *ghotul*. This chapter, which contains substantial quotations from a number of authors as well as illustrations which, however fine, are by no means strictly relevant to the Muria *ghotul*, would have been better published separately in an expanded form. The volume is more than long enough without

it, and, useful as this chapter is in itself, references would have been enough here. There are other cases, too, in which comparative matter is introduced, often with long quotations, but not always very satisfactorily. The note on ordeals should contain a reference to the remarkable report by Dr. Bor on the working of the Dafla ordeal by boiling water (*J. Asiatic Soc. Bengal*, **2**, No. 1; 1936), and the account of ultimogeniture is incomplete without reference to existing custom among the Assam tribes.

The remainder of Part 2, the whole of which occupies four hundred pages, describes the buildings of the *ghotul*, its membership, rules, dances, songs, games, recreations and ceremonies; it discusses the attitude of the Muria who use the *ghotul* to sex, marriage, morality and religion, and goes into the problem of why relations in the *ghotul* appear to be relatively infertile. There are five appendixes, including one by Mr. A. N. Mitchell on language, a glossary, an index of authorities quoted, and another of subjects. There is no proper bibliography, as the works of the authorities referred to can only be found by looking up the references in the text, and this is not always satisfactory; thus frequent references are made to Hislop *op. cit.*, but at the first reference indexed his work is already quoted as *op. cit.*, and to find the work referred to it is necessary to search back still further for a reference. Very occasionally the English tongue is misused: "prone on the back" (p. 438 twice) is a contradiction in terms; the author obviously meant 'supine'. An abbreviated glossary on a card as a book-marker is an excellent idea, but a longer list could have been got on to the card without increasing its size; and, in a volume in which vernacular terms are used in every three or four lines, such a list can scarcely be too generous.

There are 154 admirable plates, most of the photographs being of the author's taking; there are 146 figures in the text, mostly illustrating material culture and technology; and there are nine maps. In addition to these, there are plans showing dance movements, and room is found for the musical score of songs. But it is in the study of the "bachelors' dormitory" institution as an inestimably valuable asset to tribal morality and integration and to the general well-being and comfort of society that this latest of Elwin's volumes is most convincing, and, as such, it is a contribution to anthropological literature of the very first importance. J. H. HUTTON

MID-VICTORIAN METAPHYSICS

The Metaphysical Society

Victorian Minds in Crisis, 1869–1880. By Alan Willard Brown. Pp. xvii+372. (New York: Columbia University Press; London: Oxford University Press, 1947.) 25*s.* net.

TO an American professor has fallen the task of laying bare, some eighty years after the event, the nature and extent of one of the most English of institutions, namely, the Metaphysical Society. Its comparatively short life of eleven years bears no relation to its importance as a factor in the intellectual development of the nineteenth century. Indeed, the reverberations of which it is clearly the origin are rumbling around to this day, faithful witnesses to its force and character. Probably a long-range view, both in time and space, has helped; however that may be, the result is a book of sound scholarship, bearing the impress of careful investigation (nay, more, of a sensitive touch) on every page. Obviously, an examination of the kind required must have been far from easy; it could only have been undertaken by one endowed with the capacity to throw himself back into the temper of the eighteen-seventies, and yet to assess it across the span of years embracing two world wars. So much for what the author has accomplished—no mean achievement.

We now follow through the *Lebenslauf* of this remarkable experiment, touching *en route* little but the high-lights. To begin at the beginning, a small group at St. John's founded the Cambridge Conversazione Society, soon to become known as the "Apostles". Appropriately enough, there were twelve members, all of them in residence. This was in 1820. By the time that Frederick Denison Maurice came up, "The Society" (as its supporters often called it) had made Trinity its home, and how much he did for it becomes manifest as the story unfolds. The Senior University was not without its share, for the Essay Club at Oxford had captured Gladstone and Henry Acland among others. Thus, when the Metaphysical Society was born, with aims so close to those of the "Apostles", nearly a fifth of its brethren had experienced the discipline and mental rigour—not to mention the proverbial courtesy—of the older institutions. It is impossible to overlook how typically British all this was: no planning, no theories, no absolutes, and (fundamentally) no nonsense.

At this juncture, however, a man to whom the adjective 'unique' can well be applied came upon the scene. This was James Knowles, later to attain outstanding distinction as founder and editor of the *Nineteenth Century*. In November 1868, he conceived the idea of a "Theological Society", to discuss urgent problems indicated by its title. Luckily, he thought again, which led him to consult Dean Stanley (of Westminster) about it. Briefly, the proposal to set up such a body was considered unwise; it could do little but force open even wider than before the gulf dividing religion and science. Nobody seriously desired a cockpit for belief versus disbelief; in the end, Lady Augusta Stanley, the Dean's wife, suggested substituting "Metaphysical" for "Theological". Thus, all was well, and the new Society started life without knives protruding from the pockets of theists and agnostics. At this time of day, it is difficult to realize how great a diplomatic victory had been won. If liberality of intention and generosity of heart had failed at that instant, much, as we shall see later, of value in years to come might never have seen the light. It was a near thing.

A preliminary meeting to establish the Metaphysical Society was therefore held in April 1869, and the first regular meeting in June of the same year. A resolution stated, *inter alia*, that subjects like the ultimate grounds of belief, the logic of the sciences, the immortality of the soul, the existence of God, and so on, should be discussed "with absolute freedom". There were twenty-six original members, with powers to add to their number up to fifty in all. The list of names is impressive: Huxley, Tennyson, Tyndall, Gladstone, Manning, to quote but a few.

We now leave this erudite assembly to its grand debate for a short period, and look in upon it again on June 10, 1873. Archbishop Manning, in the chair, considered it necessary to announce that the Society "has been visited by symptoms of aphonia". In other words, having talked incessantly for four years,

it had now become inarticulate. Why? Because, in essence, it lacked three things, all-vital to progress in metaphysics. They were (1) a fixed and accepted terminology, (2) a common method, and (3) definition. Naturally, the first two were unlikely to be accorded much constructive sympathy, the Society being what, in fact, it was. The third fared rather better; but in any event Manning was scarcely the character to carry agnostics with him on such matters. Nevertheless, a committee was appointed to struggle with definition; who its members were is unknown. All this goes to show that the subject of semantics (or semiotics) was then in the minds of advanced thinkers, not, of course, by any means for the first time, but perhaps in a form capable of emergence later into an exact discipline.

Much of this mental strife concerned mainly the particular age covered by the Society's active life; two legacies, however, were bequeathed to posterity, and these deserve special mention. In 1875, George Croom Robertson, a member, issued a prospectus which resulted in the publication of *Mind*; and in 1879 Shadworth Hodgson, another member, founded the Aristotelian Society. How much later generations of philosophers, metaphysicians and psychologists owe to these two enterprises is hard to assess; but obviously their debt is great. Had not Lady Augusta Stanley 'intervened' at the beginning, would these two ventures ever have materialized?

In spite of all, on November 16, 1880, the Metaphysical Society died by its own hand, much, if not all, of its self-imposed duty done, and its torch, still gently aflame, passing into other hands. Members had "chattered metaphysics", as Tennyson once put it, for more than a decade, and with results little short of miraculous. Seen, nearly seventy years after death, upon the pages of Prof. A. W. Brown's stately volume, it yet represents what it always was, a company of inspired amateurs, hammering away relentlessly to liberate the truth as they conceived it, and presenting their treasure with the transparent sincerity of great Victorians.

F. I. G. Rawlins

TROPICAL AGRICULTURE

A Handbook of Tropical Agriculture

By G. B. Masefield. Pp. viii+196. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 12*s.* 6*d.* net.

THE literature on tropical agriculture is widely scattered, and it is not easy for the newcomer to tropical agriculture to find answers to the innumerable questions that he inevitably asks; hence a compilation of a general nature, such as the present work, fulfils a definite need. The book commences with an introduction consisting of five chapters dealing with tropical soils and environment, soil conservation, implements and haulage, irrigation and some economic aspects. These rather diverse topics are compressed into twenty-four pages, and while providing a useful introduction, it tends to oversimplify the various problems involved.

The second part of the book deals with various tropical crops both major and minor. Again, the scope of the book allows only a brief account of each, but will no doubt be a useful source of reference to those suddenly confronted with the entirely new agriculture of the tropics. It would have added to the value of the book, without appreciably increasing its length, if the natural orders to which the crop plants belong had been indicated.

Owing to the very different, and often specialized, agriculture of various tropical territories, very few agriculturists will have had the opportunity of acquiring first-hand information about all tropical crops, and a book of this nature (as the author admits) must depend to a certain extent on information from a variety of sources. It is not surprising, therefore, that minor errors of detail occur; for example, it is stated that one of the objects of cacao fermentation is to "develop the characteristic chemical compounds including theobromine which gives cocoa its stimulating property". Actually the reverse is the case—fermentation causes some of the theobromine already present in the bean to be released and lost in the sweatings.

Part 3 gives a general account of agricultural diseases and pests. Here the author is confronted with the difficult task of making a selection, since it is obvious that only the most important can be mentioned. It is difficult to understand, however, why the leaf-cutting ants (*Atta* spp.) of the American tropics are not included.

The concluding chapters are concerned with livestock—cattle types, small stock, minor farm animals and pasture management. There are appendixes containing information useful to the practical agriculturist.

Books on tropical agriculture are few, and the present work provides a handy reference for the general agriculturist in the tropics and is especially useful as an introduction to tropical agriculture, although the author states that it is not written for the specialist. The author's clear and concise style has enabled him to compress a surprising amount of information into a small compass.

E. C. Humphries

OCEANIC BIRDS OF SOUTH AMERICA

Oceanic Birds of South America

A Study of Species of the Related Coasts and Seas, Including the American Quadrant of Antarctica based upon the Brewster-Sanford Collection in the American Museum of Natural History. By Robert Cushman Murphy. Vol. 1. Pp. xxii+640+44 plates. Vol. 2. Pp. vii+641–1245+44 plates. (New York: The Macmillan Company and the American Museum of Natural History. London: Macmillan and Co., 1948.) £4 7*s.* 6*d.* net.

A NEW edition of this remarkable work, first published in 1936, will be welcomed by bird-lovers not only in America but also in Great Britain. The birds described, although primarily sea birds of South America, are, many of them, great wanderers, and are found either habitually, or from time to time, in North Atlantic waters. For example, consider Wilson's petrel. These petrels, writes the author, in summer are to be seen in every bay and cove of Maine and Nova Scotia, although they are migrants from the other end of the world, whereas Leach's petrels, which nest on the shores of Maine and Nova Scotia, are rarely seen on the sea. The calling of Leach's petrels during the night in their burrows, and also in the air above them, is so strange and mysterious that "the mind may readily picture a

most animated gathering of the black elves of old, hurrying to and fro for the accomplishment of some important mission, ere dreaded Day begins".

There are notes on the tremendous flights of the Arctic tern, supposedly from Pole to Pole. The following quotation is made from Forbush. "The Arctic tern is one of the most remarkable birds of the world. It is the long-distance champion of avian migration. It nests at least as far north as the most northern Eskimos live, while in winter its tireless pinions beat along the distant shores of unexplored lands of the Antarctic continent. It sees more hours of daylight and sunlight than any other creature on earth. On the arrival of the species at its northernmost nesting-site the midnight sun is shining and it never sets during the tern's stay; while for two months of its Antarctic sojourn the bird sees no sunset. For about eight months of the year it has twenty-four hours of daylight, and during the other four months more daylight than darkness. According to Professor Cooke the Arctic tern makes a round trip of 22,000 miles between its farthest north and farthest south."

Another great ocean wanderer is *Puffinus gravis*, the greater shearwater, which, from its only known breeding haunts on the islands of the Tristan da Cunha group, ranges far. During its winter, which is the northern hemisphere summer, vast numbers of these shearwaters are to be found on the Grand Banks of Newfoundland and elsewhere in North Atlantic fishing grounds.

The beautiful colour plates which were a feature of the two original volumes are again reproduced. Peruvian boobies are seen at their nesting ledges, and there is a striking illustration of the fairy tern, a bird described by the author as "most ethereal of sea birds, delicate and gentle. Their plumage is white, but with subtle ivory or creamy tones, and with a barely perceptible reddish gleam visible in certain lights on the feathers of the belly." The ornithologist will spend many happy hours with these two volumes.

SETON GORDON

CRYSTALS AND X-RAYS

Crystals and X-Rays

By Dr. K. Lonsdale. Pp. viii+199+13 plates. (London: G. Bell and Sons, Ltd., 1948.) 21*s*. net.

THE subject of X-ray crystallography has long outgrown the stage when it could be treated adequately in a single book. Since the early works of the Braggs and of Wyckoff, a large number of more specialized monographs have appeared which discuss in detail various aspects of the subject, such as the geometrical interpretation of X-ray photographs, optical principles, etc. In spite of this development, the need for a single text which covers the whole subject in broad outline still remains. It has, in fact, become more important, in view of the large and ever-increasing circle of workers who use the method in numerous branches of science and technology. For them it is essential that some general treatment of the subject in all its aspects should be available, so that they may grasp its significance and potentialities before applying it to their special problems.

This purpose might be well served by a good popular account of the subject, or by a book which introduces all the essential aspects and treats them briefly and concisely. In a sense these two approaches are combined in Dr. Kathleen Lonsdale's book. Although written in a popular style, it goes far beyond a popular treatment, and there are some sections which will certainly not be fully appreciated by the beginner. These sections, however, greatly increase the real value of the book and make it one which can be studied with profit by all the specialists in this field as well as by the novices. No one has made so many original contributions of first-rate importance to the subject as Dr. Lonsdale, and the publication of the present brief survey is an event of importance in science.

The book begins with a historical introduction dealing particularly with the state of knowledge at the time of the Laue experiment in 1912. There is an admirable and authoritative account of this famous experiment, which contains much information not generally known. One feels, however, that the achievements of chemistry up to 1912 are not quite fully appreciated. The new discovery soon transformed the science of inorganic chemistry; but it should be noted that, in the field of organic chemistry even at that date, the relative positions of the atoms in some 200,000 different kinds of molecule were accurately known.

The generation and properties of X-rays are next discussed, and, in spite of the popular style, this is not a very easy chapter to read. It is full of useful practical advice, based on long experience. The treatment of the geometry of crystals which follows is essentially descriptive rather than explanatory. The reasons for the limitation of the symmetry elements in crystals to certain simple types are mentioned; but no rigorous derivation is attempted.

The chapters which follow deal with geometrical structure determination and with the calculation of atomic and electronic distributions. These are definitely not easy chapters and are scarcely suitable for beginners. A number of advanced topics are discussed, and the brief paragraphs on intensity formulæ, Fourier synthesis and Patterson synthesis can scarcely do more than list the formulæ required. There are, however, many excellent illustrations showing the application of the various methods to structural problems.

The chapter on extra-structural studies gives an up-to-date account of primary and secondary extinction effects, illustrated by the beautiful divergent-beam methods developed by the author. The discussion on temperature effects similarly includes a brilliant survey of very recent work on diffuse reflexions for which Dr. Lonsdale herself has also been so largely responsible.

In the last chapter, which deals with the importance of the study of crystals, an amazing variety of topics are crowded together in small compass. These include interatomic and intermolecular forces, atomic radii, random and defect structures, mesomerism, hydrogen bonds, molecular compounds, fibrous and globular proteins, as well as metal and alloy structures. Many of these subjects are of great interest and importance to the chemist; but he will read with some astonishment about the part played by P^{5+} and N^{5+} ions in inorganic chemistry. It seems a pity that a more complete account of some of these important applications could not be given; but if the reader is stimulated to search elsewhere for further information, then perhaps one of the main purposes of the book will have been served.

J. M. ROBERTSON

Philosophical Studies

Essays in Memory of L. Susan Stebbing. (Published for the Aristotelian Society.) Pp. v+156. (London: G. Allen and Unwin, Ltd., 1948.) 15*s*. net.

THE authors who contribute to this neat little volume of essays combine to pay fitting tribute to a great mind. They discharge their task all the better by abstaining from writing a commentary upon the work of Susan Stebbing. What they have done is to discuss subjects that interested her and which her keen intellect had illuminated. In this way her memory is perpetuated and her place in philosophy secured.

During a life not free from controversy, she carried many of her forays to success, though it is more than likely that, were she with us to-day, she would administer a characteristically sharp rap to some of the views so generously marshalled in her honour. Thus, within less than eight-score pages, we traverse much of epistemology, ethics, psychology and the scientific aspect of history. One neither looks for nor expects cut-and-dried conclusions; the writers proffer their garlands with a certain abandon.

Prof. Stebbing assuredly selected her targets with a refined academic glee, as, for example, in her "Philosophy and the Physicists" (1937). The thrusts she delivered seem somewhat on the harsh side; maybe they were not intended to endure. Her whole being brings into relief the difference between logic bent upon truth, and æsthetics bent upon beauty. In her greatness, she lived for the former, others perhaps for the latter. But one day a 'pontiff' will arise and throw a bridge across the narrows; when that happens, the sheer weight of her thought will help to anchor it well and truly on her territory.

F. I. G. RAWLINS

Outline of Historical Geology

By Dr. A. K. Wells. Second edition, revised with the assistance of Dr. J. F. Kirkaldy. Pp. xi+356. (London: Thomas Murby and Co., 1948.) 25*s*. net.

THE new edition of Dr. A. K. Wells's "Outline of Historical Geology", which succeeds the first edition after a lapse of ten years, has been revised and greatly expanded, with the assistance of Dr. J. F. Kirkaldy. The text now runs to 340 pages, in comparison with 254 in the original edition; and the number of illustrations has been considerably increased by means of text figures specially drawn for the authors.

Apart from bringing the subject-matter up to date in the light of recent research, the scope of the work has been deliberately widened. Originally intended for the general reader and first-year undergraduates, the new edition is designed to meet the needs of students reading for degrees. While still stressing the philosophical rather than the factual aspects of the subject, readers who may wish to pursue particular topics in more detail have been provided for by the addition, at the end of nearly every chapter, of short lists of selected references.

The nature of the subject is such that there is not infrequently room for differences of opinion among experts, and, although attention has been directed to the existence of such differences, detailed discussions of controversial matters have been avoided. This is as it should be in a general text-book, and there is no doubt that this work forms an excellent introduction to British stratigraphy.

Teaching for Trades

A Guide to the Training of Workers in Manual Trades. By Alfred W. Hawkins. Pp. xi+70. (London: Sir Isaac Pitman and Sons, Ltd., 1948.) 8*s*. 6*d*. net.

DURING the last ten years there has been a marked and significant increase in the amount of attention given in Britain to vocational training. This can be partly accounted for by the introduction of the Ministry of Labour and National Service "Training Within Industry" scheme during the War to meet the labour demands of new and rapidly expanding factories. As a basis, certain elementary rules were prescribed for training foremen and other supervisors, and these were grouped into courses known as "Job Instruction", "Job Methods" and "Job Relations". The courses were based on well-known principles in educational psychology and, although necessarily limited in application, have met with a considerable amount of success.

Mr. Hawkins is obviously well-versed in "Training Within Industry" principles and, in this useful little book, uses the practical experience he has gained to elaborate methods of training which would be suitable for those who are concerned with the training of teachers of vocational and craft subjects. To the qualified teacher the book will offer little with which he is not already familiar; but it should prove most acceptable and useful to all the thousands of men and women who act as part-time teachers in technical and vocational institutions. The author does not waste words and, in quite a short space, gives some valuable advice on how to plan a curriculum, the organisation of training schemes and the keeping of records.

Farming for Industry

By R. O. Whyte. (Todd Reference Library.) Pp. 160+16 plates. (London: Todd Publishing Group, Ltd., 1948.) 7*s*. 6*d*. net.

THE three great rival claims on the use of agricultural land are the production of crops for human consumption, animal fodder and industrial purposes. Since the Second World War, attention has of necessity been chiefly directed to increasing food production; but a proper balance between these three objectives must be developed if land is to be used to full capacity and the wastage that has so often occurred in the past is to be avoided in the future. This is more likely to be achieved if the needs of industry are better understood. In the present volume the author gives much useful information as to the sources of supply, consumption and technical processes connected with the production of such commodities as leather, vegetable oils, tobacco, and textiles from animal and plant fibres.

In some cases the problems of the industry are mainly agricultural, in others economic or sociological; but, throughout, emphasis is laid on the desirability of the multiple use of all parts of the plant or animal where feasible and of the need for raising agricultural standards and improving technique to the mutual benefit of both farmer and industrialist. The book will also appeal to those interested in the origin of articles used in everyday life. From by-products of the dairy and animal industries, plastics, glues and cosmetics can be manufactured, and though of little commercial importance, fibres are obtainable from such widely differing sources as milk, soybeans, groundnuts and seaweed. The illustrations add considerably to the value of the book.

K. W.

EFFECT OF LOW TEMPERATURE ON THE ABSORPTION SPECTRA OF HÆMOPROTEINS; WITH OBSERVATIONS ON THE ABSORPTION SPECTRUM OF OXYGEN

By Prof. D. KEILIN, F.R.S., and Dr. E. F. HARTREE
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INTEREST in the sharpening, and in certain cases the displacement and splitting, of absorption bands at very low temperatures has hitherto been limited to the field of molecular physics, in so far as these changes have offered useful information on the molecular structure of a number of substances[1,2].

The marked changes in the absorption bands in the visible region of the spectrum at low temperatures were found in our experience during the last ten years to be of value in the study of cytochrome[3,4] and other intracellular catalysts, especially when their concentrations were low, or their absorption bands somewhat diffuse and masked by other pigments.

The effect of temperature upon the absorption spectra of organic substances is most marked in the aromatic series. Thus the sharpening and displacement of the ultra-violet bands of benzene and other aromatic hydrocarbons have been studied in detail[1,2,5]. Interpretation of spectra has so far been possible only for simple molecules[6,7], and for this reason little attention has been devoted to more complex molecules giving rise to selective absorption in the visible region. Up to the present time, the study of the effect of low temperature upon absorption bands in the visible region has been limited to two classes of substances, namely, the rare earths[8] and a few tetrapyrrolic compounds[9,10,11].

We owe the first observation on the effect of temperature on the absorption spectrum of biological material to Hartridge[9]. He found that the bands of oxy- and carboxy-hæmoglobin shift slightly towards the red on warming from 8° to 40° C. On the other hand, if these compounds are incorporated in a gelatine film and cooled in liquid air, the bands shift about 4 mμ towards the violet and appear much sharper to the eye than at room temperature[9]. Conant with Crawford and Kamerling[10], and Hausser, Kuhn and Seitz[11], demonstrated that porphyrins at liquid air temperature exhibit not only sharpening and shifting but also splitting of the bands.

The study of substances of biological interest at low temperatures meets with serious technical difficulties in the choice of a solvent, since quantitative measurements of light absorption require that the solution either remains liquid or that it freezes to a transparent solid. Thus Lavin, Northrop and Taylor[12] studied the ultra-violet absorption spectrum of pepsin at −100° C. by dissolving it in glycerol, whereas other workers[13] avoided the solvent difficulty by studying the absorption spectra of thin dry films of substances submitted to low temperatures.

In addition to the sharpening and splitting of absorption bands at low temperatures, we observed, under the conditions of our experiments, a very marked intensification of the bands. Sharpening and intensification of bands are, as will be shown, two independent phenomena. On sharpening, the absorption band becomes narrower, but only slightly if at all higher than the original band, and it may simultaneously undergo displacement and splitting into elementary narrow bands. On the other hand, intensification of a band consists in an increase of light absorption equivalent to an increase in the optical depth or density of the pigment. Intensification can be observed mainly with substances cooled in aqueous media which are allowed to freeze. Both sharpening and intensification of bands were found to be very valuable in the spectroscopic study of biological pigments.

Methods

Absorption spectra of biological materials in aqueous solutions, or suspensions, frozen to a translucent mass can be studied only with a low-dispersion direct-vision spectroscope, such as a microspectroscope ocular attached to a microscope and provided with a platform and double-wedge trough as previously described[14,15].

The material to be examined is placed in a 'Pyrex' glass tube, 12 mm. diameter, the end of which is flattened to form a disk of about 25 mm. diameter with an optical depth of about 2 mm. This tube is clamped concentrically in an unsilvered Dewar vessel in a vertical position, the bottom of the tube being at least 5 cm. from the bottom of the Dewar vessel. A beam of light from a 500-watt projector lamp is directed through the flattened portion of the tube on to the concave mirror of the microscope and thus through the sub-stage condenser into the microspectroscope ocular. A second sample of the same material is placed in one compartment of a double-wedge trough, the other compartment being filled with water. The trough is placed on the platform in front of the comparison prism of the spectroscope and illuminated by means of a 4-volt flash-lamp bulb. While keeping the illumination of the two spectra equal by means of rheostats in series with each lamp, the double-wedge trough is moved along the platform until the band intensities also match; that is, until the two absorption spectra are identical. At this point the optical depths of the flattened tube and the wedge trough are equal.

Liquid air is now poured into the Dewar vessel until the level almost reaches the flattened tube. By a series of brief immersions, the material in the tube is cooled to the temperature of the liquid air, and the tube is finally raised above the liquid air so that its lower end is again in the light beam. The matching of spectra is carried out as described above by adjusting the rheostats and moving the double-wedge trough. The examination of the tube while immersed in the liquid air was not feasible since liquid oxygen shows very strong absorption bands, and sufficiently pure liquid nitrogen was not available. After cooling the test sample it was found necessary, in the case of hæmoglobin and other hæmatin pigments, to adjust the position of the wedge trough until its effective depth was increased five to seven times. In other words, the absorption bands had been intensified in this ratio.

For routine examination of cooled material, the flattened tubes are removed from the Dewar vessel and rapidly examined while held in position above the condenser lens. Such examinations are often

very instructive in showing the gradual changes in absorption spectrum as the temperature of the sample rises. Throughout this study, both liquid air and liquid oxygen were used as cooling media even when only liquid air is mentioned in the description.

Effect of Low Temperature on the Absorption Spectra of Cytochrome and Other Hæmoprotein Compounds

We shall summarize here the main results obtained in the study of the effect of low temperatures on the absorption spectra of cytochrome, hæmoglobin and its derivatives, peroxidase and catalase.

Cytochrome

The study of cytochrome was carried out on cells of yeast and bacteria, on thoracic muscles of bees and a horse-heart preparation, spermatozoa as well as on solutions of pure cytochrome *c*.

Yeast cells. The highly aerobic cells of *Torulopsis utilis* show a typical absorption spectrum of cytochrome with very strong bands: *a*, 603; *b*, 564; *c*, 550; and *d*, 522 mμ, band *a* in this yeast being much stronger than in other micro-organisms. On cooling a suspension of yeast to the temperature of liquid air, all the bands become intensified about five times and are shifted about 5 mμ towards the violet. What is more interesting, however, is that a sharp and narrow band, which will be described as band *e*, appears between *b* and *c* at about 552 mμ. As the temperature rises, band *e* rapidly disappears, and although bands *b* and *c* still remain intensified the space separating them becomes somewhat obscured. The new band may either belong to an additional peak of one of the components of cytochrome (*b* or *c*) or to an independent component invisible at room temperature. However, neither cytochrome *c* in solution, nor cytochrome *b*, which is the only component visible spectroscopically in aerated cells treated with urethane, shows an additional peak in this region at the temperature of liquid air. It is therefore more likely that the band *e* belongs to an independent component, cytochrome *e*, which may function as an essential link in the chain of catalytic activity of the cytochrome system. In fact, as we shall see presently, this component can be detected under similar conditions in a great variety of aerobic cells and is probably as widely distributed as are cytochromes *a*, *b* and *c*. In some micro-organisms, such as certain strains of *Bacillus subtilis* and different species of *Acetobacter*, the absorption band of component *e* appears to be stronger than those of the other components. In all cases studied, the band *e* is visible only when all other components of cytochrome are in the reduced state.

Another noticeable feature in cooled cells is the fine structure of the α-band of reduced cytochrome *c*. Not only is the band markedly reinforced, but also a very fine satellite band appears close to its short-wave side. This splitting of the band was found to be general for cytochrome *c*, both in cells and in solution.

Bacillus subtilis: vegetative forms and spores. Strain No. 85 of the National Collection of Type Cultures shows a typical four-banded absorption spectrum with band *c* stronger than band *b*. On cooling cells in liquid air, the bands are intensified five to seven times, band *b* being now stronger than band *c*, and a very narrow band *e* appears at about 552 mμ. On the other hand, in strain No. 2586 (now known as *B. licheniformis*), bands *b* and *c* are normally fused to give the band b_1 lying at 550–562 mμ. On cooling a suspension of this strain in liquid air, a very sharp and strong band appears at 552 mμ, while two narrow faint bands appear lying close to and on each side of this sharp band. It appears that in this strain of *B. subtilis*, the band b_1 is a complex formed by fusion of three bands, *b*, *e* and *c*, in which the band of the component *e* greatly predominates.

The respiratory activity of spores of *B. subtilis* is very low[4], and their cytochrome content, unlike that of vegetative forms, is also very low; in fact, it is usually imperceptible even in the thickest suspensions. However, the absorption spectrum of cytochrome becomes distinctly visible at the temperature of liquid air. It has even been possible to determine that the cytochrome content of spores represents about 6 per cent of the cytochrome found in the vegetative forms[4].

Thoracic muscles of bees show a very distinct cytochrome with bands *a* and *c* much stronger than *b*. The space between the bands *b* and *c* appears exceptionally wide and clear. Muscles of six to eight bees, collected as previously described[16], are pounded with a little glycerol, spread in a thin layer upon the inner surface of a test-tube and frozen in liquid air. On spectroscopic examination, the cooled muscle pulp shows marked reinforcement of all bands, and the band *e* at about 552 mμ is here exceptionally distinct and strong. The satellite band lying very close to the short-wave side of the band *c* is also very clearly seen.

The heart muscle preparation used was the colloidal suspension obtained from washed and ground muscle by a method previously described[17]. In the presence of sodium succinate, it shows a typical absorption spectrum of reduced cytochrome with an exceptionally strong band *a*. On cooling such a preparation in liquid air, all bands are intensified as usual and the narrow band *e* appears between *b* and *c*. Heart muscle preparation is also suitable for the study of component a_3, or cytochrome oxidase. As we have shown[3], carbon monoxide combines only with the divalent iron of a_3, whereas cyanide combines with the iron in both the divalent and trivalent states. The absorption bands of divalent a_3CN and a_3CO appear on the short-wave side of the band *a*, partly merging with it. In freezing and further cooling a preparation showing a_3CN, its absorption band is intensified, but not so much as that of *a*, and the space between them does not become clearer. On cooling the preparation containing a_3CO, its absorption band disappears completely, whereas that of *a* is intensified. This phenomenon, which is perfectly reversible, is difficult to explain. It may be due either to the dissociation at low temperatures and in light of a_3CO, to the shift of its band towards the red, or else to the fact that, not being greatly intensified by cooling, it is masked by the strongly intensified band *a*.

Spermatozoa both of mammals[18] and of sea-urchins[19] show a characteristic four-banded cytochrome spectrum. In these cells the bands *a* and *c* are much stronger than the band *b*, and the space between *b* and *c* is somewhat obscured. On cooling a suspension of sea-urchin spermatozoa in liquid air, all the bands of cytochrome show a very marked reinforcement; but, what is more interesting, the additional band *e*, which now appears at about 553 mμ, becomes as strong as *b*. As the temperature rises, this band disappears leaving a general absorption which obscures the whole region between bands

b and *c*, a phenomenon which to a lesser degree could be observed in all cases previously examined. The disappearance of the band *e* takes place before the intensities of other bands are appreciably lowered. The same results, but somewhat less pronounced, can be obtained with ram spermatozoa.

Ascaris lumbricoides. The cytochrome content of tissues of this parasitic helminth is too low to be perceptible on direct spectroscopic examination. However, if the tissues, especially the hæmoglobin-free ovaries, are cooled in liquid air, the bands of cytochrome become clearly visible.

Cytochrome c in solution. When a solution of reduced cytochrome *c* is cooled to the temperature of liquid air, its absorption bands are intensified about six times and shifted by about 10 mμ towards the blue. In addition to the splitting of the α-band referred to above, there is also an increased complexity of the β-band which appears to have several additional peaks. Cytochrome *c* in solution did not differ in any way from that in the cells and tissues examined above. A solution of reduced cytochrome *c* at *p*H above 13 does not show the splitting of its α-band on cooling.

Oxidized cytochrome *c*, like other parahæmatin compounds, shows another interesting temperature effect: when boiled, its colour turns from reddish-brown to yellowish-brown and its absorption bands disappear. On cooling the solution to room temperature, these changes are reversed and its catalytic power is found to be unimpaired[10].

Hæmoglobin and its Derivatives

Oxyhæmoglobin was the first biological substance examined for the effect of low temperatures on its absorption spectrum[9]. On cooling in liquid air, the absorption bands of twice recrystallized oxyhæmoglobin and of the carbon monoxide derivative are reinforced about five times and shifted by about 5 mμ towards the blue. The single band of deoxygenated hæmoglobin, the diffuse bands of alkaline hæmatin and hæm, and the sharp bands of pyridine hæmochromogen are similarly intensified. A sharpening and splitting of the bands of porphyrins has already been described by Conant and his co-workers[10].

Methæmoglobin, or ferrihæmoglobin, is the oxidation product of hæmoglobin. As is well known, it exists in two forms. At *p*H below 6·8, the brown acid methæmoglobin is formed which shows a characteristic band in the red at about 632 mμ. At high *p*H, methæmoglobin is transformed into the red alkaline form which shows two distinct bands at 545 and 575 mμ with a narrower band at 600 mμ. It behaves, in fact, as an indicator with $pK = 8{\cdot}1$. At *p*H 9·5 it is completely in the alkaline state.

When acid methæmoglobin at *p*H 6 is cooled in liquid air, its absorption band at 632 mμ is greatly intensified and slightly shifted towards the blue. On the other hand, when alkaline methæmoglobin at *p*H 9 is cooled, it changes its colour and its absorption spectrum to those of the acid form. If one assumes that the sixth octahedral position around the iron atom of acid methæmoglobin is occupied by a molecule of water, the formation of alkaline methæmoglobin would involve loss of a proton instead of addition of hydroxyl ion[21]. The shift in equilibrium observed on cooling could then be ascribed to a suppression of ionization.

Similar changes in colour can be observed on cooling solutions of some indicators. Thus a red solution of phenolphthalein (*p*H 10) becomes colourless when cooled to −15° C. Under similar conditions phenol red (*p*H 7·8) turns from red to yellow, methyl red (*p*H 5·4) turns from orange-red to yellow, and bromthymol blue (*p*H 7·8) becomes yellow. Indicators can be considered as weak bases or weak acids the colours of which are determined by the degrees of dissociation of their tautomeric forms. Below a certain temperature cooling affects the colour of an indicator by suppressing the dissociation, a phenomenon which is general for electrolytes[22].

Catalase and Peroxidase

In colour, absorption spectra and in reactions with certain substances, catalase and peroxidase show marked resemblance to acid methæmoglobin[23,24]. On cooling the solutions of these enzymes in liquid air, their absorption band in the red is greatly intensified and shifted 7–9 mμ nearer the blue end of the spectrum. Although in some cells these enzymes are present in high concentration, owing to the relatively weak and diffuse nature of their absorption bands in the red, they cannot be easily seen on direct spectroscopic examination of the tissues. However, on cooling in liquid air, slices of previously perfused liver or of strips of horse-radish 2–3 mm. thick, the absorption bands in the red of catalase and peroxidase respectively can be clearly seen. Peroxidase, like methæmoglobin but unlike catalase, shows very marked changes in colour and absorption spectrum with changes in *p*H [24]. At *p*H above 11, a reddish alkaline form of peroxidase is obtained with bands at 574 and 545 mμ. When cooled, alkaline peroxidase, like alkaline methæmoglobin, changes its colour and absorption spectrum to those of the acid form.

Effect of Low Temperature on Certain Other Substances

Although sharpening and intensification of absorption bands have been observed for many substances when cooled, the phenomena are far from being general. In fact, as has been mentioned above, the suppression of ionization on cooling may, in the case of certain indicators, bring about a change or a complete suppression of their colours and absorption bands. The same applies to a number of basic dyestuffs, the colours of which fade to varying degrees. Thus methylene blue on cooling turns pale pink, a phenomenon which has previously been recorded[25], while the deep violet Wurster's salt becomes almost completely colourless.

Influence of Physical State on the Sharpening and the Intensification of Absorption Bands

At very low temperatures, in addition to sharpening, the five- to seven-fold intensification of absorption bands was invariably obtained when material was frozen to a microcrystalline mass of ice. The relationship between the sharpening and intensification of bands was, in the first instance, studied on the readily available technical didymium nitrate dissolved in 50 per cent glycerol. Salts of didymium, which is a mixture of neodymium and praseodymium, show in the visible region of the spectrum a series of absorption bands of different intensities. The experiment is carried out with a dilute, practically colourless solution of didymium nitrate in 50 per cent glycerol, just showing two of its bands at 575 and 521 mμ in a layer of 2 mm. occupying the flattened portion of the tube. The latter is rapidly cooled in liquid air, which causes the solution of glycerol to solidify to a transparent glass. The tube is then

removed from the Dewar flask, and spectroscopic examination of its flattened portion held above the condenser lens now shows that the absorption bands of didymium are sharpened but only very slightly intensified. This absorption spectrum persists as long as the solidified glycerol retains its glass-like transparency; in other words, while it remains in a vitrified state.

On keeping the flattened portion of the tube in the same position, and allowing its temperature to rise, a point is reached when the colourless vitrified mass acquires an amber colour, the phenomenon beginning at the periphery and spreading rapidly towards the centre. At the same time the vitrified mass becomes only slightly opalescent, and on spectroscopic examination shows the bands of didymium still sharpened but intensified only two to three times. The amber colour of the vitreous mass soon disappears and is replaced or masked by a marked opalescence due to the devitrification or crystallization of the solidified mass of aqueous glycerol. The intensity of the absorption bands now rapidly increases, and when the devitrification is complete it reaches more than fifteen times that of the original material. If at this stage the preparation is again cooled in liquid air, the greatly intensified bands undergo distinct sharpening with the reappearance of their fine structure. During the second cooling the material remains in the crystalline state; and when eventually it is allowed to warm up, the absorption bands, after losing their sharpness and fine structure, gradually decrease in intensity while the solvent still remains in the crystalline state. Solid didymium nitrate or didymium glass on cooling show sharpening of their bands with only slight intensification. It should be noted that the transient amber coloration of vitrified glycerol during warming is not due to the presence of didymium, since it can be observed with pure 40–50 per cent glycerol treated in a similar way. In fact, this phenomenon was previously observed[26] as marking the onset of devitrification of solutions of sucrose vitrified by rapid cooling.

Results in every respect similar to those recorded for didymium were obtained with oxyhæmoglobin, reduced cytochrome *c*, the complete cytochrome system of heart-muscle preparation and cells of *Torulopsis utilis*, dissolved or suspended in 50 per cent glycerol. In all these cases, on rapid cooling in liquid air, the vitrified material shows mainly the sharpening of bands with the appearance of fine structure. On warming the preparation, the onset of devitrification is marked by an amber coloration and by a two- to three-fold intensification of the absorption bands. With more advanced devitrification, the amber colour disappears, the material becomes more opalescent and its colour due to pigment becomes much deeper. At the same time the intensity of the absorption bands rapidly increases, reaching more than fifteen times that of the original material. The fine structure of the bands brought about by their sharpening, which with the rise of temperature becomes obliterated and replaced by an intensification, can be regained on rapid cooling of the preparation in liquid air. This final treatment thus gives material with absorption bands which are both highly intensified and sharpened.

In all these experiments, glycerol can be replaced by a strong solution of sucrose as well as other solvents which with rises in temperature pass from vitrified to crystalline states. Once the devitrification on warming has set in, it cannot be reversed by cooling but only arrested. Thus each phase in the successive changes in colour and band intensities of a pigment during the devitrification of the solvent, however transient it may be, can be stabilized by a rapid cooling of the preparation in liquid air, when the intensified bands become sharpened.

The experiments summarized above clearly show that we are dealing here with two independent phenomena: (1) sharpening of the bands accompanied in certain cases by their displacement and splitting; and (2) marked intensification of colour and of absorption bands.

(1) Sharpening of bands of certain substances has been extensively investigated by previous workers[1,2,5,10,11]. In cases where the absorption curves have been plotted, the bands at very low temperatures were found to be narrower and higher than at room temperature or even split into elementary bands, while the area beneath the curves was very little changed.

Sharpening of the bands is a pure temperature effect and is intimately linked with the molecular structure of the substance. In fact, even closely allied substances show different degrees of sharpening, displacement and splitting of their bands at very low temperatures[10].

(2) The marked intensification of colour and absorption bands has not been noticed by previous workers, who have been at pains to avoid crystallization of the solvent. Yet it is only when the crystallization does take place that this phenomenon can be observed. There is no doubt that the striking intensification of the bands is a purely optical effect, and that a marked increase in the effective optical depth of pigment is obtained by an interplay between a light-absorbing substance and the light-reflecting surfaces of the micro-crystalline mass of solvent. In fact, a strong although less pronounced intensification of absorption bands can be obtained at room temperature by treating a solution of a didymium salt with dry kieselguhr which consists of minute highly ornamented silica shells of fossil diatoms. For this purpose a didymium salt solution is placed in a cylindrical flat-bottomed tube to a depth of 2 mm., the concentration being such that scarcely any colour or absorption bands are perceptible. Sufficient kieselguhr to absorb all the fluid is then added. The mixture, compressed to a disk, appears reddish in transmitted light and on spectroscopic examination shows a very pronounced intensification of the bands at 575 and 521 mμ. Similar results are obtained with solutions of oxyhæmoglobin and cytochrome *c* and to some extent with cytochrome of colloidal heart muscle preparations. The minute silica shells of kieselguhr probably act here as multiple reflecting surfaces simulating the microcrystalline mass of devitrified material in our previous experiments. Kieselguhr in some of these experiments can be replaced by pounded crystals of Iceland spar, by talc or by kaolin.

Absorption Spectrum of Oxygen

We have already mentioned that the absorption spectra of substances cannot be studied while they are immersed in liquid air since liquid oxygen itself shows very sharp absorption bands in the visible region. The fact that liquid oxygen, and to a lesser degree liquid air, are bluish in colour is familiar to all who handle them, but that it also shows sharp absorption bands in the visible region of the spectrum is far from being generally known. This is not surprising

considering that the very interesting literature on this subject, going back as far as 1885, has not yet received due recognition in text-books. We shall therefore briefly summarize the main results obtained in this field, and describe a few simple confirmatory experiments which could well be introduced as interesting class demonstrations.

In 1885 Janssen[27] reported the presence of five absorption bands in the visible region of the spectrum of oxygen examined in a 60-metre tube at a pressure of 27 atmospheres: the two bands nearer the red end of the spectrum corresponded to the Fraunhofer lines *A* and *B*. In the following year[28], he found that the intensity of the other three diffuse bands varied as the square of the pressure (Janssen's law), which explained why they were not seen in the solar spectrum although clearly visible in the equivalent amount of oxygen under pressure. Janssen calculated that with his spectroscope it should be possible to see the most intense of these bands, namely, that at 577 mμ, when the sun was 4° above the horizon, that is, when twelve to fifteen times the vertical depth of the earth's atmosphere is traversed by the sun's rays. Observations carried out in the clear air of the Sahara Desert confirmed this view[29].

Liveing and Dewar (1889–95)[30] made a more detailed study both of gaseous air in a depth of 18 metres at a pressure of 97 atmospheres as well as of liquid air and liquid oxygen. They recorded ten absorption bands between 760 and 343 mμ, confirmed Janssen's law and found that there was no sudden change in intensity of bands during the transition from gaseous to liquid oxygen at the critical point. More recently, the absorption spectra of gaseous, liquid and solid oxygen have been carefully investigated, and about forty bands have been recorded in the visible and ultra-violet regions of the spectrum[31,32,11]. An important experimental and theoretical contribution to the study of the problem is that of Salow and Steiner[33]. Janssen's law has been explained on the basis of an equilibrium $2O_2 \rightleftharpoons O_4$, the absorption bands at wave-lengths greater than 650 mμ are those of di-atomic oxygen (O_2), whereas those at lower wave-lengths, which obey Janssen's law, are due to tetra-atomic oxygen (O_4). The formation of the latter can be followed by measurements of magnetic susceptibility[34]: whereas di-atomic oxygen is paramagnetic, tetra-atomic oxygen is diamagnetic. It is of interest to recall that diamagnetic oxyhæmoglobin is also formed by a reversible combination of two paramagnetic molecules, hæmoglobin and oxygen.

The absorption spectrum of oxygen can easily be observed in liquid air in a non-silvered Dewar flask of about 3 cm. internal diameter, by means of a direct-vision hand spectroscope. The bands, which are at 625, 557 (most intense), 530 and 482 mμ, are very sharp, and in this respect are somewhat reminiscent of the bands of the rare earths (for example, didymium salts). On allowing liquid air to evaporate, its bluish colour deepens and the bands become stronger as the concentration of oxygen increases.

Matching of absorption spectra of liquid oxygen and liquid air was carried out by means of the microspectroscope outfit, the layer of liquid oxygen in one Dewar flask being reduced to any required optical depth by inserting into the flask glass tubes of known diameter. It was found that the absorption bands of liquid oxygen in a depth of 0·29 cm. matched those of 5·33 cm. liquid air. The liquid oxygen was about 98 per cent pure, and if x is the percentage of oxygen in the liquid air then it would follow from Janssen's law that $0{\cdot}29 \times 98^2 = 5{\cdot}33 \times x^2$, or $x = 23$ per cent. The liquid air was thus slightly enriched in oxygen. This experiment gives additional quantitative evidence that Janssen's law holds for oxygen in the liquid state.

We also made a comparison of the spectra of liquid and gaseous oxygen. For this purpose we used a steel tube fitted with a needle valve and with glass windows designed to withstand high pressures (we are greatly indebted to Prof. D. M. Newitt for the loan of this tube). The optical depth between windows was 60 cm. At 120 atmospheres, oxygen showed the bands at 625, 557 and 482 mμ very distinctly, the 557 mμ band being still visible at 30 atmospheres. Using the microspectroscope outfit, we found that the absorption bands of 0·29 cm. liquid oxygen matched those of the gas in the steel tube filled to 84 atmospheres. Assuming that the purity of the oxygen was the same in both cases and that the density of liquid oxygen is 850 times greater than that of the gas at room temperature (18° C.), if x is the optical depth of liquid oxygen the absorption spectrum of which should, according to Janssen's law, match that of 60 cm. oxygen at 84 atmospheres pressure, we can write: $60 \times (84)^2 = x \times (850)^2$, whence $x = 0{\cdot}58$ cm. which is exactly twice the experimental figure. In other words, there is a two-fold increase in band intensity on cooling and liquefying oxygen, which is in agreement with some of the previous observations[31].

Conclusions

(1) Since freezing and further cooling to a very low temperature sharpens and intensifies the absorption bands of certain pigments, spectroscopic examination of such cooled material offers an additional and very valuable method for the study of biologically important pigments in cells, tissues and their aqueous extracts. Such observations can be carried out only with a small dispersion spectroscope.

(2) This method has made possible the detection and comparative estimation of cytochrome in cells of low respiratory activity where the pigment has not hitherto been seen.

(3) It has revealed the presence of component *c* of cytochrome with an absorption band lying between bands *b* and *c* in cells where it would otherwise be invisible. This component (*c*) appears to be as widely distributed as the other components of cytochrome, forming part of the same catalytic system.

(4) It has made possible the direct observation of catalase in perfused hæmoglobin-free liver and of peroxidase in strips of horse-radish root.

(5) Cooling, by suppressing the ionization of certain substances such as *p*H indicators, changes or completely suppresses their colour and their absorption bands.

(6) When the alkaline forms of methæmoglobin or of peroxidase are cooled, their colours and absorption spectra change to those characteristic of their acid forms.

(7) While some coloured substances exhibit sharpening and intensification of absorption bands at low temperatures, others are characterized by a change in the spectral pattern or even a suppression of the bands. Cooling of a mixture of substances, therefore, often brings into prominence a component the absorption bands of which were previously masked.

(8) Solutions or suspensions of coloured substances in 50 per cent glycerol can be frozen in liquid air to transparent glasses the absorption bands of which

show sharpening but very little intensification. If such glasses are warmed until devitrification sets in, there is a rapid and very marked intensification in colour and absorption bands: the latter may become more than fifteen times as intense as the bands of the original uncooled material. On re-cooling the mixture, the intensified bands become sharper and show the fine structure.

(9) The changes in absorption spectra referred to above are the results of two independent processes:

(*a*) Sharpening of the bands, often accompanied by their shifting and splitting, which is observed in absence of solvent, in solvents which do not freeze, and in solvents which freeze to transparent glasses. This process requires very low temperatures and depends upon the molecular structure of substances.

(*b*) Marked intensification of bands, which is equivalent to a corresponding increase in the optical depth of the coloured substance and which occurs only in solvents freezing to a crystalline mass. This effect is generally obtained when a light-absorbing substance is associated with microcrystals, or other suitable particles present in the medium, which provide properly distributed multiple reflecting surfaces.

(10) Finally, attention has been directed to important literature concerning the sharp absorption bands of oxygen in the visible region of the spectrum, and simple experiments have been devised whereby these bands in gaseous and liquid oxygen can be easily demonstrated and studied with a small dispersion spectroscope.

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SOME OBSERVATIONS ON THE MODE OF ACTION OF PENICILLIN

By PETER MITCHELL

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THE effects of a toxic substance upon a cell are not instantaneous. There is always a course of events leading up to the changes, reversible or otherwise, which are imposed upon the organisation of the normal cell by a toxic substance. The action generally occurs in two stages. In the first stage, the toxic factor reacts with certain components of the cell. In the second, and from some points of view more important stage, the organisation of the cell changes because of the impairment of function of the components directly affected by the toxic factor. The second stage does not, of course, occur until the activities of the cell involve the operation of the components of which the function is impaired; and so it may readily happen that only when the cell is disturbed from a state of rest does the action of a toxic substance become apparent or lethal.

Such is the case in the action of penicillin upon sensitive organisms. In cells which are resting or respiring, but not growing, although there is evidence of reaction of the penicillin with components of the cells[1], no other changes are apparent. The occurrence of growth, however, is accompanied by progressive cytological[2,3] and metabolic[4,5] disturbances. At first the changes are reversible[6,7], but as they progress they become irreversible and death of the cells follows[8]. It is evident that whereas penicillin does not interfere with the activity of any system which normally operates during respiration of non-growing cells, it does interfere with some system which is active during growth.

After a short period of growth in bactericidal concentrations of penicillin, the mechanism which is responsible for the accumulation of glutamic acid in several Gram-positive organisms is damaged[9], and it has been suggested that the starvation of the cells of glutamic acid which is thus caused might be sufficient to account for the bactericidal action. This thesis is strengthened by the observation that most of the organisms which are sensitive to penicillin accumulate free glutamic acid, and that, generally, the more efficient the accumulation mechanism, the more sensitive is the cell to penicillin[10]. The first stage in the action of penicillin cannot, however, involve its reaction with any component of the system which causes the accumulation of glutamic acid, for penicillin has no effect upon this system in resting cells. There must be at least one intermediate step. The simplest possibility is that the penicillin reacts initially with components of a system responsible for the synthesis of some essential part of the glutamic acid accumulation mechanism.

So far, the system which has been found to be most closely associated with the first stage in the action of penicillin is that responsible for the dissimilation of nucleotides, for the breakdown of nucleotides is inhibited by penicillin in resting cells[11,12]. Consequently it is natural to consider that the disturbance of nucleotide balance may be the step which precedes the damage to the mechanism responsible for glutamic acid accumulation in growing cells, and that a knowledge of the time-course of the changes in nucleotide – nucleic acid balance in

relation to cell-growth should assist in integrating our view of the course of events.

At my suggestion, an experiment was carried out (reported in an account of some of the work of the Medical Research Council Chemical Microbiology Unit at Cambridge by Gale[13]), which showed promise of yielding some of the information required. A study has now been made of the progress of the growth and of the total nucleic acid content and the content of nucleotide extractable with 5 per cent trichloracetic acid of *Staph. aureus* (Duncan) in a casein digest medium containing 'Marmite' and 1 per cent glucose, in the presence and absence of 1 μgm./ml. (1·7 Oxford units/ml.) of penicillin.

The percentage by weight of total nucleic acid was estimated by a spectrophotometric method[14], of which the basic assumption is that the percentage decadic absorption coefficient of 'nucleic acid' is 200 at a wave-length of 260 mμ. The percentage by weight of nucleotide was also estimated photometrically on the same basis. (If it is considered preferable to express the results as absorptions rather than as weights, it is only necessary to multiply by the factor 200.) The estimation of growth (dry weight in μgm./ml. = DW) was made with turbidity measurements at a wave-length of 350 mμ, accompanied by calibrations based on direct dry-weight determinations from which an index of scattering power k, defined by the expression

$$\log_{10}\frac{I_0}{I} = \frac{k(DW)}{350},$$

was obtained. The cultures were held at 25° C. instead of the usual 37° C. so as to extend the time-scale and make it easier to separate the stages in the progress of penicillin action.

The progress of percentage weight of total nucleic acid, percentage weight of nucleotide extractable with trichloracetic acid, the ratio of extractable nucleotide to total nucleic acid content and $\log_2 DW$ are shown in Fig. 1 for a normal culture and a culture containing 1 μgm./ml. (5 μgm./mgm. cells) of penicillin.

In the normal growth, the percentage of nucleic acid rises during the lag and early lag phases and falls again during the decline of growth, confirming earlier findings[15]. The percentage of nucleotide extractable with 5 per cent trichloracetic acid, on the other hand, is highest during the lag phase, at the end of which it falls rapidly. Of the factors plotted, as would perhaps be expected, the ratio of extractable nucleotide to total nucleic acid content shows the most constant value once the phase of lag is over. It will be noticed that the scattering coefficient k shows a small dip in the earlier part of the decline of growth, but is otherwise fairly constant.

After the addition of penicillin, there is a transient rise in percentage of total nucleic acid, of which a large part is accounted for by the proportionately greater rise in percentage of extractable nucleotide, while the ratio of extractable nucleotide to total nucleic acid shows a progressive increase. On the other hand, after a delay of about half an hour, the scattering power of the cells rises precipitately to a final value 70 per cent higher than for normal cells. Consequently, direct turbidimetric measurements of the rate of growth in penicillin give erroneously high values. When the necessary corrections are made, it is found that after a delay of about half an hour, the apparent mean generation time is approximately doubled until, at the end of four hours, there is a

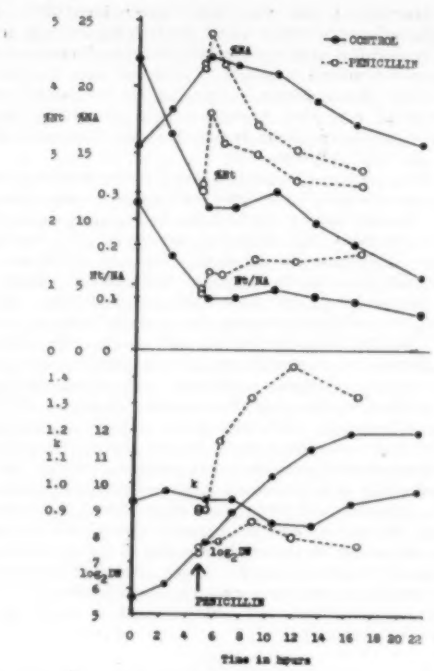

Fig. 1

NA = total nucleic acid content;
$\%NA$ = percentage by weight of total nucleic acid;
Nt = nucleotide extractable with 5 per cent trichloracetic acid;
$\%Nt$ = percentage by weight extractable nucleotide;
DW = dry weight in μgm./ml.;
k = index of scattering power, defined by $\log_{10}\frac{I_0}{I} = \frac{k(DW)}{350}$.

sudden cessation of growth and appearance of lysis. The change in extractable nucleotide seems to begin earlier than the change in growth-rate.

Fig. 2 shows the values of percentage extractable nucleotide and the absorption spectra of extractable nucleotide fraction of the cells determined at ten-minute intervals after the addition of penicillin in an experiment otherwise similar to that described in Fig. 1.

The rise in percentage of extractable nucleotide begins immediately on addition of penicillin and continues at a more or less uniform rate for an hour, and accompanying the change in amount there is a change in absorption spectrum.

In the experiments which have just been described, the total nucleic acid measurements were made on samples of the culture after washing free from medium. To determine whether the rise in percentage of total nucleic acid is accompanied by an actual stimulation of purine-pyrimidine synthesis, an experiment was designed in which the purine-pyrimidine content of the cells and medium were estimated directly in the growing culture. Because of the very large ultra-violet absorption of the casein digest medium, however, it was necessary to dilute it twenty times with a solution of 0·2 per cent glucose.

When cells grown in the normal medium to the stationary phase were transferred to the diluted medium, there was little or no growth during the first two hours. The early part of the lag period was

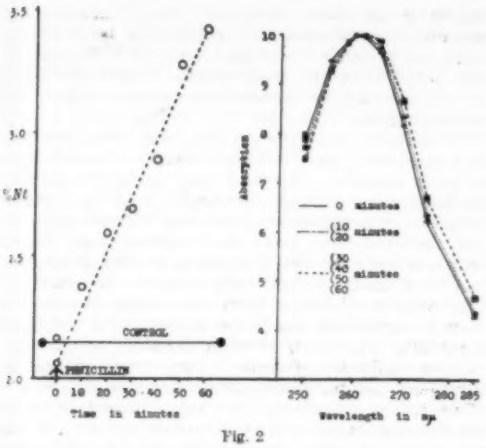

Fig. 2

accompanied by a decrease in the total nucleic acid content of the cells and a smaller increase in the purine–pyrimidine content of the medium, evidently caused by loss from the cells. This process soon became reversed, the cells taking up purine–pyrimidine material from the medium. The lag was terminated quite sharply by the appearance of logarithmic growth and the cessation of accumulation or loss of purine–pyrimidine bodies in the medium. From the beginning of the log phase, the changes in total nucleic acid content of the cells consequently represent purine–pyrimidine bodies synthesized or broken down by the cells, there being no net accumulation from the medium.

The progress of percentage of total nucleic acid (*NA*), $\log_2 DW$ and $\log_2 NA$ of such normal and penicillin-treated cultures is shown in Fig. 3, the amount of penicillin per unit volume and per unit cell mass being the same as in the previous experiments.

For the normal growth, the slope of $\log_2 NA$ is constant for more than two hours, but less than the slope of $\log_2 DW$, which is also constant, and hence there is a linear decrease in percentage by weight of total nucleic acid over this interval. This throws some light on the process whereby the percentage by weight of total nucleic acid changes with the age of the culture during normal growth. In the phase of negative growth-acceleration, where growth becomes slower because of impoverishment of the medium, the

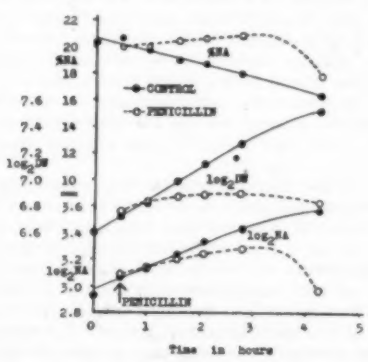

Fig. 3

decrease in percentage of nucleic acid is not due to a degradation of nucleic acid for formation of other cell constituents as might be supposed, but to an alteration of the relative rates of formation of nucleic acid and of total cell mass. It is surprising to what extent these rates appear to be independent.

In the presence of penicillin, the slope of $\log_2 DW$ decreases more rapidly than that of $\log_2 NA$, showing that the rate of formation of total cell mass decreases faster in the penicillin than the rate of production of total nucleic acid. The effect of this is to cause an increase in the percentage by weight of nucleic acid, as has already been observed in the previous experiments. The mean generation time is now 4 hr., however, in place of 1·4 hr. in the rich medium, and the time taken for the percentage of nucleic acid to reach its maximum is correspondingly extended by a factor of about 3. Thus we may conclude that the initial rise in the percentage of nucleic acid in the penicillin-treated cells is not accompanied by a net stimulation of purine–pyrimidine synthesis, but is caused by a small decrease in the relative rate of formation of components other than nucleic acid which contribute to the dry weight of the cells—possibly the cell proteins.

At the time of writing, a paper has appeared which describes some changes in the composition of the nucleotide fraction of *Staph. aureus* after 35 min. growth in the presence of 1 unit per ml. of penicillin[14]. The observation to which the authors attach most importance is that there is an accumulation of labile phosphate in the nucleotide fraction of penicillin-treated cells, confirming an earlier finding[12]. They attribute the labile phosphate to the presence of a particular unidentified substance. This substance is reported to have an absorption maximum at 262 mμ, and may be one of the components causing the changes in the nucleotide fraction reported here. The time-course of the changes in the labile phosphate concentration during the growth of a culture has not apparently been determined, however, either for normal or for penicillin-treated cells. The same authors[14] have attempted to confirm the original observation[12] that penicillin causes a relative drop in the rate of synthesis of ribonucleic acid (and thus a fall in the percentage of total nucleic acid), but consider their results to be in experimental conflict with the original findings. The reason for the disagreement may be explained by the fact that the percentage of total nucleic acid first rises and then falls in penicillin-treated cells, so that whether the percentage of total nucleic acid is observed to rise or fall in a given experiment is determined by the concentration of penicillin and the duration of the penicillin treatment.

To summarize: A progressive disturbance of the nucleotide nucleic acid balance, accompanied by a change in composition of the nucleotide fraction, commences immediately after the addition of penicillin to the growing culture. This appears to be due to a net slowing of the rate of polymerization and not to a stimulation of synthesis from precursors. The nucleotide disturbance occurs simultaneously with, or is followed shortly by, an increase in the percentage by weight of total nucleic acid, due to a slowing of the rate of formation of total cell mass relative to that of nucleic acid, the absolute rate of formation of nucleic acid being only slightly affected at this stage. The increase in the percentage of total nucleic acid is followed immediately by a somewhat less rapid decrease towards a final low value similar

to that found in normal old cells, the later part of this process, if not also the earlier part, being accompanied by autolytic activity. The light-scattering power of the cells rises precipitately at about the time when the percentage of total nucleic acid reaches its peak, and it is thus evident that pronounced physical changes must take place at this point.

The course of events is consistent with the view that the penicillin reacts initially with components involved in nucleotide dissimilation, and that the disturbance of nucleotide balance which follows in the growing cell leads immediately to other complex changes. We have no clear indication how the changes in the nucleotide fraction of the cells affect the glutamic acid accumulation mechanism, if, indeed, there is any direct effect at all. But there seems little doubt that the glutamic acid accumulation mechanism is not affected until after the major changes in the nucleotide fraction have already taken place.

I wish to express my indebtedness to Dr. E. F. Gale for valuable criticism and advice, and to the Medical Research Council for a personal grant.

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SYMBOLS AND NOMENCLATURE

By Sir CHARLES DARWIN, K.B.E., F.R.S.

THE Symbols Committee of the Royal Society has met at intervals during recent years to consider various matters brought to its attention, including not only questions of symbols in physics and chemistry, but also to some extent of units and of terminology. These subjects have also been discussed at recent meetings of the International Unions of Chemistry and of Physics, and of the Conference of Weights and Measures (see *Nature*, March 19, 1949, p. 427), and it would scarcely be possible to consider those activities separately. It is thought that readers of *Nature* may find it useful to have a brief account of these important, though perhaps not very exciting, matters, and the task has been remitted to me. Though I think there is general agreement on the part of the Committee, I must take all responsibility for the views expressed here.

In 1937 there was appointed a committee of the Chemical, Physical and Faraday Societies to prepare an agreed list of symbols covering their joint interests. This list was embodied in a pamphlet which came into widespread use, and it was (with slight modifications) adopted in 1939 by the Royal Society. In 1947 the International Union of Chemistry considered the subject and adopted a system broadly based on the same principles, though making permissible some alternative symbols that have been in wide use in other countries. In 1948 the same list was adopted by the International Union of Physics at its meeting in Amsterdam, again with a few slight changes.

In addition to all the fundamental quantities such as length, force, etc., the list primarily concerns those of joint interest to physics and chemistry, such as thermodynamical and electrical quantities, and it would be out of place to describe the detail here. On the physical side there is, however, one serious omission from the list of symbols in that no attempt has been made to deal with symbols for elasticity. The subject is studied from very different points of view by physicists and by engineers, and it is scarcely surprising that their different demands should have led to different symbols; but even among the physicists and mathematicians there is no consistency. Thus in some notations, the symbol p_{xy} is used for the tensor component of stress—though not always with the same sign—but the corresponding e_{xy} for strain is not a tensor component, but the double of it. Again, among different writers the letter σ is used as stress, as dilatation, and as Poisson's ratio. With several authoritative text-books using different long-established notations, there is little hope of achieving unity; but there might be at least one notation—of necessity different from all of them—systematically worked out so that it should be self-consistent. An attempt was made to put one forward at the Amsterdam meeting; but it will certainly be some time before anything more can happen about it.

In this connexion it is curious to note the popularity and unpopularity of various letters for use as symbols for physical quantities. The 26 Roman and 24 Greek letters, both capital and small, seem to provide quite a number of choices; but many of them, like x or π, are obviously unsuitable, and, indeed, there really is something of a shortage of letters available for any new quantity. But it is scarcely an overstatement that when a writer wants a symbol for a new thing, it is more than probable that he will call it either μ or σ, and the shortage is really not so great as all that. Many of these duplications are harmless because they deal with quantities so different that they will never occur together; thus there is no reason why μ should not stand for coefficient of friction, and coefficient of viscosity (as used by Lamb, though η is now the adopted symbol) and for refractive index (n is now preferred). But it is getting a little dangerous to use it both for magnetic permeability, and for the moment of the magneton. Some of the uses of σ have been mentioned above; but the reader can no doubt think of others. On the other hand, certain letters are practically unused, in particular β, and it is difficult to see why; it is true that it is often used in the trio α, β, γ, and this might be a reason against its use for other purposes; but for the fact that α and γ have a great many other uses.

One of the most important decisions made at the Amsterdam meeting, now finally endorsed by the Conference of Weights and Measures, was to adopt the joule as the unit of heat instead of the calorie. A consequence of this is that the mechanical equivalent of heat disappears from among the list of universal constants, and becomes merely the numerical value of the specific heat of water. The change-over will be certainly troublesome, as are all changes of units; but the definition of the calorie is so confused

that something had to be done, anyhow. Since the measurement of heat is now usually done electrically, it gives an answer directly in joules, and it is a retrograde step to translate it into calories. The agreement made at Amsterdam was that where a paper gives results in calories, it must state what the conversion factor is that is being used. This course seems scarcely enough in order to get the joule into real use, so that workers should come to *think* in terms of joules instead of calories. The various scientific societies are being consulted as to the best way of bringing this about. It has to be recognized that it will take time to get used to the unfamiliar unit, and the method that is being explored is that, for example, heats of reaction should always be given in joules, but that the author, if he likes, may add the value in calories afterwards in parenthesis. An essential part of this proceeding must be the preparation of conversion tables, together with a critical review of the matter, since many workers are quite unaware what a vague expression the calorie really is.

Now that the long-established mechanical unit, the joule, is to assume so much greater importance, there is one matter in connexion with it that should be decided, and that is how the word is to be pronounced. There was not long ago a correspondence on the subject in *Nature* (**152**, 354, 418, 479, 602; 1943) which revealed the most surprising disagreement, and more recent inquiries among various people in Manchester confirm these doubts. Some make the great man's name rhyme with 'cool', some with 'cowl', and some even with 'coal'. Thus, Sir Arthur Schuster called him 'Jowl', while Prof. H. B. Dixon, who had a curiosity in such matters, said the name was disyllabic as 'Jo-ull', which would be nearly 'Joal'. On the other hand, Osborne Reynolds in his memoir on him, though he never states how the name is spoken, mentions that it derives from the village of Youlgreave in Derbyshire from which his family came, which would make it 'Jool', and this is the preference of at least some of the surviving family. However all this may be, the word is now to be international, and it is unreasonable to make foreigners suffer from the horrors of English orthography; it therefore seems best that the joule as a unit of heat should rhyme with the word 'cool'—of course, giving the initial 'j' its proper English value.

On the subject of temperature, the Amsterdam conference adopted the sound principle that there should be only one fixed point on the absolute scale instead of the present two, and that this point should be the triple point of water, suitably chosen so as not to alter the existing scale. It will take a little time before this can take effect, because there is still some doubt about the second decimal place of the absolute zero. At the same time, a minor change of nomenclature was agreed—that the name 'centigrade' should no longer be used, but that the scale should be called 'Celsius'. This is the practice already in many countries, and the objection to the word 'centigrade' is that with the present systematization of nomenclature a centigrade ought to mean a hundredth of a grade (the French unit of angular measure, or the German degree), and that the word would be useful for that purpose.

There was a rather strong drive from some quarters at the Amsterdam Conference to replace the C.G.S. by the M.K.S. system of units. This seems to be a subject which runs the danger of being carried by a few enthusiasts against a rather indifferent majority. The Conference took the sensible line of accepting it as admissible; but it very definitely did not recommend that the C.G.S. system should be abandoned by physicists. To some of us this seems important, because the proposal to convert all measures into M.K.S. would put out of date practically every physical table ever printed, changing every number by some troublesome power of ten, and this to very little purpose indeed.

A committee at Amsterdam discussed at some length a proposal for rationalizing the units in radioactivity; the story runs curiously parallel to that of the heat units. The unit used hitherto has been the curie, which was originally defined as the quantity of radon in equilibrium with a gram of radium, but which has gradually come to be used for other substances simply as a measure of the number of disintegrations per second. Some have felt this to be inappropriate, since radium has now the same sort of unimportance in atomic disintegration that water has in the measurement of heat, and it was recently proposed in the United States that a new unit, the rutherford, should be introduced as signifying a million disintegrations a second. The subject involves all the difficulties associated with every proposal for a change of well-established units, and it was finally referred to a joint committee of the Unions of Physics and Chemistry which, it is proposed, will supersede the International Commission on Radium Standards. In the meantime, it is proposed as a temporary measure that the 'international curie' should signify $3{\cdot}6 \times 10^{10}$ disintegrations a second; this number (in place of $3{\cdot}7 \times 10^{10}$ which has hitherto been used) was adopted as the best rounded number according to recent work in America.

In the nuclear field another small matter of terminology may be noted. The Amsterdam conference attempted to dispose of the curious modern theory that the ancient Greek termination for a fundamental particle was '-tron'. It blessed the word 'meson' as against its rivals, and proposed the adoption of 'positon'.

The Symbols Committee has also given consideration to a number of minor points of notation and vocabulary which have arisen from time to time. There is no intention in these of dictating to authors what they should use; but it was felt that there are a number of matters in which a lead might be given, since some writers may be indifferent and may like guidance. The list is extremely miscellaneous, and many of the suggestions are already in widespread use; some of them have arisen from queries addressed by authors to the Royal Society.

(i) There is the tiresome confusion over the use of lb. or kg. both as measures of mass and of force. To introduce wholly new names for one or other seems impossible at the present time, and to write kg. (mass) is very clumsy. A suggestion made years ago by Prof. Stroud, of Glasgow, seems to provide a reasonable compromise. This is that the force unit should be denoted by a capital letter, so that a mass of 1 lb. or 1 kg. when hung on a string exerts a tension of 1 Lb. or 1 Kg. Again, in a pV diagram as used by the engineer, the ordinate is Lb./in.^{2} and the abscissa in.^{3}/lb.

(ii) There is great confusion over the meaning of the 'atmosphere', as there are no less than three possibilities. It would no doubt be scientifically best to use the 'bar' or million dynes per cm.^{2}, but this has not been accepted yet in common practice; it is 75·006 cm. of mercury. Then there is what is called the 'technical atmosphere', used by engineers

in Europe, which is defined as 1 Kg./cm.^{2}; it is 73·555 cm. of mercury for the standard value of gravity. For physics, however, it is agreed that the standard atmosphere should be 76 cm. of mercury at 0° C. and with g = 980·665 cm./sec.^{2}. It is proposed that only the last should be accepted as the meaning of 'atmosphere'.

(iii) For work on vibrations it is often convenient to use not the frequency itself, but this quantity multiplied by 2π. Various names have been proposed for this, but none has gained any very wide acceptance. It is proposed that the most suitable name is 'radian frequency', which brings out the contrast to 'cyclic frequency'.

(iv) There have been various words adopted from the German without translation, and this is a clumsy practice. One was 'Nullpunktsenergie', for which the translation 'zero-point energy' has gradually grown up. This is an ugly word; but it expresses the idea correctly and has already been widely accepted. Another is 'Bremsstrahlung', for which no translation has been found. The German name is bad itself, because the connexion with braking is very remote, and it is an awkward word for an English mouth. It is not easy to think of a name that would give a really significant description of the effect, and it is suggested that 'brake-radiation' would be no worse a misdescription than the German word.

(v) The English practice has hitherto tended to be to use the symbol 'log' for both natural and common logarithms, and when there is danger of confusion to put a subscript e or 10. The practice of denoting the Naperian logarithm by 'ln' has much to commend it, and then 'log' will signify only the common logarithm. The subscript would then be mainly used only when the base is neither e nor 10, though it is always possible in case of doubt to retain it for the common logarithm.

(vi) The word 'super-sonic' is sometimes used in two entirely different senses, one for motions faster than the speed of sound, and the other for acoustic vibrations of pitch too high to be audible. It is suggested that it should only be used in the first sense, and that the word 'ultra-sonic'—on the analogy of ultra-violet—should be always used for high-pitched vibrations.

RESEARCH LABORATORIES OF THE GENERAL ELECTRIC COMPANY

THE Research Laboratories of The General Electric Co., Ltd., entertained at Wembley more than three thousand guests, including men of science and members of other research organisations and industrial concerns, at a conversazione held on June 21–23.

These Laboratories, a pioneer industrial research organisation, were founded in 1916 when the late Sir Clifford Paterson (then a principal assistant at the National Physical Laboratory) undertook the formation of a research department for the lamp works of the Company. By 1923, when the Laboratories built at Wembley were formally opened by Lord Robert Cecil and Sir J. J. Thomson, so many requests for collaboration had been received from other sections of the Company that the original plans had already been extended and the scope of the work considerably increased. The Laboratories now cover a floor area of 200,000 square feet and employ nearly 1,400 personnel, of whom more than 500 are scientific and experimental staff. The scope of the organisation becomes apparent when it is realized that each works and technical department in The General Electric Co. requiring scientific advice is represented by a group of workers in the Laboratories.

There are some thirty-four such units in addition to service groups of analytical chemists, metallurgists, X-ray workers, spectroscopists and others, the services of which are generally available throughout the organisation. The predominant note in the work of all these groups is the giving of scientific service to industry, with two important departures—the fostering of fundamental research which may give new knowledge of ultimate use in industry, and the solution of practical production problems associated with the manufacture of new products of the Company.

No event comparable to this conversazione had been held at the Laboratories since their inception, and it was expected that much of the work carried out there might be almost unknown to a large number of the invited guests. In their speeches of welcome, Sir Harry Railing, chairman and joint managing director of the Company, and Mr. O. W. Humphreys, manager of the Research Laboratories, emphasized their desire that the achievements of the Laboratories should be made known to as wide an audience as possible, both among men of science and the lay public. In order to give visitors a clear picture of the everyday work of the Laboratories, the number of special exhibits was kept to a minimum, and, as far as possible, work was proceeding normally. The fullest freedom of discussion between guests and staff was encouraged in order to achieve the true spirit of a conversazione.

Many of the activities in the field of lighting and illumination were on view. High-pressure mercury-vapour lamps, ranging from 125 watts to 25 kW. rating, were shown and their construction described. Fundamental research is carried out on the properties of the discharge itself, and a very highly loaded flash-discharge lamp is being used to study the behaviour of extremely high current discharges. The latter has application for photographing particle tracks in a Wilson cloud chamber. Recent improvements in the colour-rendering properties and the increased luminous efficiencies of mercury-vapour lamps have extended their applications, both for street lighting and for illuminating motion-picture and television studios. Complementary work on carbon arc lamps also attracted attention.

The qualitative visual assessment of the colour and colour rendering of fluorescent discharge lamps was demonstrated, some of the newest fluorescent materials being shown. The colour appearance of some objects, particularly foodstuffs, is often dependent on the illumination used, and experiments in which their appearance is assessed by a panel of observers were shown in progress. The design and testing of street-lighting lanterns and of fittings for interior lighting were also demonstrated.

Samples from each batch of lamps manufactured by the Company are tested for length of life and luminous performance. The racks for the routine testing of tungsten filament, tubular fluorescent, high-pressure mercury vapour, neon and sodium lamps were on view. Photo-electric photometers are used for making accurate routine measurements of

the luminous efficiency of these lamps, initially and throughout life. A spherical integrating-photometer, 12 ft. in diameter, has recently been built and is used for measurements on tubular fluorescent lamps up to 10 ft. in length, as well as large lighting fittings.

Of the large number of projects in the field of telecommunications in hand at the Laboratories, a few deserve particular mention. Concerning pulse-modulation, demonstrations of an experimental 24-channel pulse-system were in progress. The signals can be compressed at the transmitter and expanded at the receiver, thus considerably improving the signal-to-noise ratio in this type of communication. Apparatus for generating very short pulses, of the order of 0·01 μsec. duration, was on view.

A system, using the frequency bands 70–72·8 and 85–87·5 Mc./s., has been developed to provide a long-distance six-channel multiplex circuit using radio links. This system uses wide-band frequency modulation. Intermediate stations, spaced about every fifty miles, may use a simple combination of terminal-type transmitters and receivers or may incorporate a special type of non-demodulating radio-repeater.

In order to cover the greater area required in fixed-mobile communication, as, for example, in systems used for police cars, a very high frequency modulated system has been developed. Instead of using a single transmitter, several remote transmitters are used and their transmitting frequencies synchronized. This synchronization is obtained by radiating signals of multiplied and divided frequency to the satellite stations, where they are divided and multiplied and re-radiated. The talk-back signals from the cars are received at either master or satellite stations, the whole system being arranged to operate without the attendance of operators other than the message dispatchers.

A wide selection of cathode-ray tubes, valves and components was displayed. Intensive research on secondary emission is carried out, and valves employing one or two stages of secondary emission, in use as wide bandwidth amplifiers, were shown. Visitors also saw high back-voltage germanium point-contact rectifiers, based on the old 'cat's-whisker' principle. The current-voltage characteristic of such a germanium rectifier was displayed on an oscillograph screen and compared with that of a low back-voltage silicon type.

An item of exceptional interest was the new germanium triode amplifier and oscillator. This device consists of two point-contacts mounted close together and in contact with a piece of germanium material which forms the third electrode. The necessity for manipulative skill in its manufacture has been greatly reduced in a new type which can be made quickly and efficiently by accurate machining only. This triode operates with a negative voltage of the order of 20 volts on the anode and a small positive voltage on the grid, no heater being necessary.

All valves, germanium crystals and Geiger–Müller counters manufactured by the Company undergo the same rigorous life- and performance-tests as lamps, and visitors were able to see the apparatus with which these are carried out.

The alloys of which valve-cathode-filaments are made must lie within close composition specifications, and the technique of powder metallurgy, used in their manufacture, was demonstrated. This technique is also used for making 'G.E.C. Heavy Alloy', which is composed of tungsten, nickel and copper and has a density of about 17 gm. per c.c. 'Heavy Alloy' is therefore particularly suitable for making screens against harmful radiations and for radium containers, the purpose for which it was originally developed. Another major use is in the aircraft industry, for balancing ailerons, rudders and elevators and in crankshaft balance weights for aero engines.

The new method, developed in the Laboratories, for welding aluminium and its alloys without the application of heat has recently aroused much interest. The main factors ensuring the satisfactory use of this cold-welding process are the preparation of the surface to be welded and the design of the tools used. Examples of the many possible types of structures and joints were shown, and practical demonstrations given.

The high precision necessary in the manufacture of magnetrons was demonstrated by two machines which carry out the grooving and slotting respectively. The former machine automatically cuts the strap grooves in magnetron anode blocks, without leaving any burr in the holes or slots. The slotting machine cuts the radial slots, which connect the central bore with the planetary holes, to a minimum width of 0·004 inch.

Development work on diamond dies for drawing the very fine wires used in lamps and valves is carried out at the Laboratories, and visitors were shown experimental work on the various methods used for piercing holes of correct profile through diamond.

Sapphire crystals, for use as gramophone needles, and for jewel bearings in instruments, are synthesized, either in the form of 'boules' or long rods. The automatically controlled furnaces, in which fine alumina powder is converted into the required crystalline form, were shown.

A large number of demonstrations connected with the manufacture and working of glass was given. General glass-blowing and hand bulb-blowing was in progress, while equipments for measuring the creep of refractory materials, the devitrification temperature of glass and the low-temperature viscosity of glass aroused considerable interest.

This brief summary cannot adequately cover the varied activities of the Laboratories as shown to its guests. The motive underlying the occasion is best expressed in the words of Mr. Leslie Gamage, the vice-chairman and joint managing director of the Company. When addressing visitors from the Press on the second day of the conversazione, he said: "We want you to feel that we are always ready to try to give you the information you may need, and to answer any questions you may have. Only if those who carry out research are in the closest possible touch with those who will ultimately benefit from that work can we achieve our aims and can our efforts reach full fruition."

OBITUARIES

Mrs. R. H. A. Plimmer

VIOLET GERALDINE SHEFFIELD, whose death occurred on July 4, became the wife of R. H. A. Plimmer before her academic career was far advanced. She had one son and three daughters, and she applied her scientific training and knowledge to the rearing of them in a thoroughly wholesome and healthy

manner. She became intensely interested in the influence of nutrition on health and made it her especial study. Her husband became interested in it also, and, in addition to his pioneer work on the structure of the proteins, he carried out experiments on the influence of vitamin B on the nutrition of different birds, for example, hens, guinea fowls, turkeys, etc. Prof. and Mrs. Plimmer jointly wrote a book entitled "Food, Health and Vitamins", which was first published in 1925. By 1942 it had reached its ninth edition. In this, they quoted from Browning:

"Man must pass from old to new,
From vain to real, from mistake to fact,
From what once seemed good, to what now proves best:
How could man have progression otherwise?"

To discard "what once seemed good" for "what now proves best" has been their guiding principle throughout their scientific writings. Prof. and Mrs. Plimmer wrote "Vitamins and the Choice of Food" in 1922, thus bringing within the reach of everyman knowledge which was then in its very early infancy, the only vitamins then known being A, B and C. Mrs. Plimmer alone produced "Food Values at a Glance" in 1939, which was found to be of very great value to people who had to cater for schools and other large fraternities as well as those who had to feed only a family. Later, in 1941, she wrote "Food Values in Wartime", a most practical and readable book for people who seriously tried to make the best of the war-time rations. To many people, it probably brought the first indication that the choice of food should be guided by influences other than mere taste. A second edition was published in 1943. Mrs. Plimmer's writings must have had a very far-reaching effect on the health of the British people, not only during the War but also in the even harder catering times since it ended. Her readers as well as her many personal friends will miss her kindly and understanding help. KATHARINE H. COWARD

Mr. F. S. Smythe

THE sudden death on June 27 of Francis Sydney Smythe, the well-known mountaineer and writer, has removed one who for a considerable number of years has brought home to the public in effectual manner both the beauty of great mountains and the supreme adventure of climbing them. This he did in some twenty or more books, apart from numerous articles, relating to the Alps and the Himalayas especially, and it is significant that it was his last visit this year to the beloved Himalayas which was the cause of his decease through infection from some unknown germ.

As a boy Frank Smythe was delicate, and in consequence, after a period at Berkhamsted School, he was sent to Switzerland, where his love of mountains grew to full maturity. There, too, he received some of his training at Zurich as an electrical engineer. But a brief appointment in the Argentine convinced him that engineering was not his *forte*, and he returned to England to engage in a severe struggle to establish himself in article-writing, relating mainly to his Alpine and British mountaineering experiences.

The international expedition to Kangchenjunga in 1930 gave him his first taste of Himalayan mountaineering, out of which experience grew his successful ascent of Kamet (25,447 ft.) in 1931, and his three attempts on Everest with the expeditions of 1933, 1936 and 1938. In another field, that of the Canadian Rockies, his last success in 1947 was in the pioneer ascent of Mount Lloyd George, in northern British Columbia, where his natural force and skill seemed quite unabated. I was a member of this exploratory expedition and can bear witness, moreover, to Smythe's habitual enthusiasm for the mountain flora, which was found in surprising profusion in that far northern district.

The collecting of mountain plants, particularly in the Himalayas, was the chief adjunct of his climbing enterprises, and as a result many of these plants have been acclimatized and introduced into English gardens, notably his own beautiful one in Sussex. But Kew and Edinburgh were the recipients of many new or rare species, especially from the central Himalayas of Garhwal, whence in the course of one expedition he brought back some 250 varieties. This achievement was described in his book "The Valley of Flowers", published in 1938, which was well illustrated in colour.

As a photographer Smythe was in the first class, and his more recent books were often albums of beautifully artistic subjects and views, with minor text as commentary. He died at the early age of forty-eight, having been twice married, and leaving three sons by the first marriage. N. E. ODELL

WE regret to announce the following deaths:

Mr. Charles Day, a past-president of the Institution of Mechanical Engineers, on June 18, aged eighty-one.

Prof. Ottavio Munerati, director of the Sugar-beet Experimental Station, Rovigo, Italy, on July 18.

Prof. P. E. Newberry, O.B.E., formerly Brunner professor of Egyptology in the University of Liverpool, on August 7, aged eighty.

Sir Frank Stockdale, G.C.M.G., C.B.E., vice-chairman of the Colonial Development Corporation, a leading authority on Colonial agriculture, on August 3, aged sixty-six.

NEWS and VIEWS

Earthquake in Ecuador

ON August 5 a great earthquake, immediately followed by two severe and many lesser aftershocks, struck the South American Republic of Ecuador. A preliminary account may now be given though further news from the affected area and from observatories throughout the world is awaited. The area most affected was that lying between the two volcanic peaks of Chimborazo and Cotopaxi. Casualties may be more than nine thousand dead and twenty thousand injured, and damage to property has been estimated at over £5,000,000.

The epicentre was near the towns of Pellileo, Patate and Pillaro, Guano and Salcedo, which are now virtually in ruins. Ambato, some seventy miles south of Quito and once the fifth largest city in Ecuador, famed as an agricultural and commercial centre, has 80 per cent of its buildings down. In particular the cathedral and the Civil Guard barracks were badly damaged and some people inside them at the time killed; water supplies, other public services and communications were cut. Rescue work is pro-

ceeding. Latucunga, midway between Quito and Ambato, Pujilo and Squisili, Lamerced and San Francisco and many other places in the vicinity were all badly shaken. Quito itself does not appear to have been greatly damaged. Messages from the observatory at Quito state that the earthquake was tectonic in origin and not volcanic. Faulting took place and giant fissures opened with accompanying landslides. Roads were destroyed; the Quito–Guayaquil and other railways were blocked; rivers, including the Patate, were also blocked by changes of level and by debris with consequent flooding; land levels were altered.

The area concerned, being part of the Pacific ring of instability, is liable to earthquakes, though fortunately in recent years the epicentres of great earthquakes have been away from densely peopled areas in Ecuador. The epicentres of the earthquakes of 1929 and 1933 were in the sea, though the latter affected the Santa Elena peninsula to some extent (*Nature*, November 18, 1933, p. 779). Earthquakes in the eastern Andes region of Ecuador occurred in 1919, 1924, 1927, 1928 and 1930, and earthquakes, probably of volcanic origin, occurred near Chimborazo in 1924 and 1927, and near Cotopaxi in 1934. In 1939 an earthquake cracked buildings in Vallechillos (*Nature*, February 11, 1939, p. 238). By far the largest earthquake in Ecuador was on February 4, 1797, when Quito was badly affected and some forty thousand lives were lost in the country.

University of Birmingham

Prof. Humphrey Francis Humphreys has been appointed to succeed Prof. M. L. E. Oliphant, who retires from the post on September 30, as vice-principal. Prof. Humphreys was educated at Bromsgrove School and the University of Birmingham. After graduating, he went for a time to the Dental School of Harvard University and later travelled extensively in America, Japan, Malaya, Burma and India. On his return he went into partnership as dental surgeon with his father, the late John Humphreys, the distinguished archæologist, who played a leading part in the creation of the Dental School of the University. In the First World War Prof. Humphreys served in the East and commanded a cavalry field ambulance in the advance into Syria in 1918, gaining the M.C. In 1919 he resumed his dental practice and was appointed lecturer in dental anatomy in the University. After being assistant-surgeon at the Birmingham Dental Hospital he became an honorary surgeon in 1925. In 1934 he was appointed an honorary physician to the King, and in the following year he became professor of dental surgery and director of dental studies in the University. During 1939–46 he was colonel in command of the Fourteenth General Hospital. In 1946 he was appointed deputy lieutenant for Warwickshire. Prof. Humphreys is also a member of the Advisory Committee of the University Grants Committee, the Nuffield Provincial Hospitals Trust, the Medical Research Council and Birmingham Regional Hospital Board.

Dr. F. Morton, reader in chemical engineering, has been appointed to the second chair of chemical engineering in place of Dr. Stacey Ward, who was recently appointed to the chair of mining. Dr. Morton, who was born at Sheffield, is an M.Sc. and Ph.D. of the University of Manchester. He was chief chemist to Trinidad Leaseholds, Ltd.

Mr. John Murphy has been appointed professor of industrial metallurgy to succeed Prof. Leslie Aitchison, who has retired owing to ill-health. Mr. Murphy graduated at the University of Manchester and has been on the scientific staff of the Department of Metallurgy at the National Physical Laboratory. He is chief metallurgist of J. Stone and Co.

Prof. T. Thorvaldson

The issue of the *Canadian Journal of Research* (Section B, Chemical Sciences) for April 1949 is dedicated to Prof. Thorbergur Thorvaldson by his friends and students on the occasion of his retirement as director of the Chemistry Department in the University of Saskatchewan. Prof. Thorvaldson was born in Iceland, but was brought up from childhood in Canada. After graduating in the University of Manitoba, he worked on thermochemistry and the determination of atomic weights under T. W. Richards and G. P. Baxter at Harvard University. He was awarded his doctorate at Harvard in 1911, and devoted the next two years to electrochemical and photochemical researches with F. G. Donnan at Liverpool and R. Luther at Dresden, respectively. In 1914 he was made assistant professor of chemistry in the University of Saskatchewan, and five years later he became head of the Chemistry Department, which he has directed with much distinction for thirty years. Well known as a teacher of analytical and physical chemistry, he is also widely known for his series of fundamental researches on the chemistry of cement and the preparation and physico-chemical properties of its constituents. In recognition of his scientific work, Prof. Thorvaldson was elected a fellow of the Royal Society of Canada in 1926, and more recently the Government of Iceland conferred on him the dignity of a knighthood of the Order of the Falcon.

The Petroleum Times (1899–1949)

The well-known technical periodical *The Petroleum Times* has recently celebrated its golden jubilee in a manner fitting alike to a great industry—its *raison d'être*—and to itself. The jubilee number contains a review of the evolution of British oil development during the past fifty years, the story being told in serial form covering successive five-year periods. Starting with some notes on the founding of the journal and on pioneers in the oil industry, the first five years (1900–4) are considered to be the lamp-oil era; the next period (1905–9) is one of laying solid foundations, the grasp of what the word petrol is destined to mean to the world in general and to Great Britain in particular. 1910–14 brings a spurt in commercial development with the overcoming of technical and fiscal obstacles, culminating in the First World War, which, whatever else it did not do for mankind, certainly brought the industry to maturity and placed petroleum in the forefront of international commerce. The first-war period 1915–19 is a record of crises in oil supplies, desperate searches for substitutes, measures of government control and, thereafter, the extraordinary development of the oil resources of the world.

The American scene dominates the general picture until 1924; the Russian influence of oil marketed in Great Britain at undercut prices is clear in the ensuing period until 1929; and then comes the flood-tide of American oil production during 1930–34 and its large-scale consequences on the industry

all over the world. Succeeding this period is the approach to sanity, orderliness and healthy competition, with explorations, new discoveries, technical developments on an unprecedented scale, leading up to the 1939 calamity. The period 1939–45 is rightly described as when "The Industry Gives its All", with petroleum 'in action' as never before. The last phase, 1946–49, "The Threshold of Freedom", reveals that struggle is still going on in the oil world as in other spheres of human activity. This jubilee number is beautifully produced and illustrated, and, as a permanent record of fifty years of British achievement in the petroleum industry and in the making of this periodical, it should find a place in every oilman's library.

New Plant Diseases

THE life-history of *Ramularia onobrychidis* is described by S. J. Hughes in a recent paper (*Trans. Brit. Mycol. Soc.*, **32**, Pt. 1, 34; 1949). This fungus causes a leaf spot of sainfoin: it produces chains of conidia from spring to early autumn, and also makes sclerotia in winter. The latter remain viable for a considerable period, and produce conidia from the neck cells. Pathogenicity of the fungus has been proved by inoculation with conidia; but no perithecial stage has yet been found. Another leaf spot of sainfoin, caused by *Septoria orobina*, has also been described by the same author (*ibid.*, pp. 60–62). W. C. Moore mentions three new fungal plant diseases (*ibid.*, pp. 95–99). *Zythia fragariæ*, which is responsible for a leaf blotch on strawberry, can also produce similar damage on *Geum*. A downy mildew on *Alyssum saxatile* was found due to *Peronospora galligena*. Downy mildew of the vine, *Plasmopara viticola*, has probably been confused with powdery mildew on the same host; but several authenticated records in England are now given. A fourth malady, black heart of potato, is non-parasitic; it may be due to unsatisfactory clamping conditions, though it is possible that the symptoms were induced by high soil temperature while the tubers were still attached to the parent plant.

New Insecticides

A CONCISE report on many of the newer insecticides has been prepared by a committee of the Mushroom Growers' Association, Yaxley, Peterborough (12 pp., 2*s*. 6*d*. net, April 1949). D.D.T., 'Gammexane', azobenzene, hexaethyltetraphosphate and tetraethylpyrophosphate are described in some detail, and parathion (*E* 605), velsicol 1068, Dynone II and piperine are also mentioned. Methods of application are discussed. The report is in the nature of a grower's guide, and more experimental work must be done before any overall recommendation can be made.

Earthquakes During May

ELEVEN strong earthquakes and many minor ones occurred during May. All the major ones had their epicentres in well-known seismic zones, and fortunately most were either in the sea or in uninhabited places on land. No really deep-focus earthquakes were among them, though at least three had deeper foci than is normal, namely, those on May 3 in the Kurile Islands, and on May 8 and 30 off the coast of northern Chile. These were also three of the four strongest shocks of the month, the fourth being the earthquake on May 9, with a normal depth of focus, and epicentre near the coast of north-west Sumatra. Three local shocks are also worthy of note. The first, on May 1, was felt at Horta in the Azores; the second was in southern California and was felt at Santa Monica, Los Angeles, Blythe and Elsinore with scale 4 (Modified Mercalli scale); the third was in France in the Departments of Nièvre and Saône et Loire, being felt in the former at Château-Chinon and in the latter at Anost with scale 3–4 (Modified Mercalli scale). Readings of instrumental records have been received from the central stations of the United States Coast and Geodetic Survey and Strasbourg, and from individual observatories at Cleveland (Ohio), De Bilt (Netherlands), Durham, Edinburgh, Kew, Stuttgart and Toledo.

Diploma in Animal Genetics at Edinburgh

THE University of Edinburgh has recently instituted a diploma in animal genetics. The course lasts one year, during which students spend about half their time attending lectures and practical work, and during the remainder undertake directed research or attend other suitable courses in the University. Candidates should be honours graduates in a biological subject or in mathematics, or must otherwise satisfy the University of their fitness to enter the diploma course. It is expected that, during the coming year, Prof. Sewall Wright of Chicago will be in Edinburgh as a Fulbright visiting professor and will take part in the course.

International Union of Nutritional Sciences

IN connexion with meetings of the Committee of the International Union of Nutritional Sciences, to be held in Copenhagen during September 12–14, it has been arranged to hold some scientific sessions and visits to institutes of nutritional interest in the neighbourhood of Copenhagen between Monday and Friday, September 12 and 16, inclusively. It is thought that this may be of interest to a wider circle of nutritional workers, and those interested are invited to communicate with Prof. H. Dam (Biology Department, Polytechnic Institute, Østervoldgade 10 L 11, Copenhagen, Denmark), or Dr. Torben K. With (Rigshospitalet, Copenhagen, Denmark), who are taking charge of the local arrangements.

Announcements

THE following have been elected to Beit Fellowships for Scientific Research of the value of £500 per annum each, tenable at the Imperial College of Science and Technology: A. R. Boothroyd, for research in electrical engineering under the direction of Prof. Willis Jackson; G. E. Gadd, for research in aeronautics under the direction of Prof. A. A. Hall; J. T. Law, for research in physical chemistry under the direction of Prof. H. V. A. Briscoe.

DR. J. R. M. INNES, formerly of the Institute of Animal Pathology, University of Cambridge (1926–40), and head of the Subdivision of Pathology, Biological Laboratories, Imperial Chemical Industries, Manchester (1940–47), has been awarded a special research fellowship by the United States Public Health Services, Division of Mental Science. Dr. Innes will work at the Microbiological Institute, National Institutes of Health, Bethesda, Maryland, on demyelination encephalopathy in lambs and dogs.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Effect of X-Rays on the Incorporation of Carbon-14 into Animal Tissue

In a recent note[1], it was shown that irradiation of rats with X-rays diminishes very pronouncedly the rate of incorporation of carbon-14 into desoxyribonucleic acid. Simultaneously, an *enhanced* incorporation of carbon-14 into the total proteins of the organs was observed. This observation induced the investigation of the effect of irradiation on the incorporation of carbon-14 in the whole tissue.

About one microcurie of carbon-14 incorporated with the carboxyl group of sodium acetate was injected subcutaneously into each of an aggregate number of 180 one- to three-week-old rats and full-grown mice, respectively. The animals were killed after the lapse of about eight hours, and the radioactivity of the dried kidney, intestinal mucosa, liver and muscle tissues was determined. Half the animals had been previously irradiated for three minutes with a total dose of 950 r. (in air), the voltage applied being 165 kV. A significant increase in the incorporation of carbon-14 in every sample investigated was observed. The figures in the accompanying tables show some of the results obtained in experiments with rats (*A*) and mice (*B*).

Table *A*. Incorporation of carbon-14 in the tissues of rapidly growing rats following the administration of labelled acetate (dose 950 r.)

Organ		Arbitrary activity figures	Per cent increase in carbon-14 incorporation due to irradiation
Kidneys	Control	22·05	16·8
	Irradiated	25·74	
Intestinal mucosa	Control	12·83	31·8
	Irradiated	16·93	
Liver	Control	11·20	13·5
	Irradiated	12·70	
Muscles	Control	22·05	16·7
	Irradiated	25·74	

Table *B*. Incorporation of carbon-14 with the tissues of full-grown mice

Organ		Arbitrary activity figures	Per cent increase in carbon-14 incorporation due to irradiation
Kidneys	Control	20·2	40
	Irradiated	28·3	
Intestinal mucosa	Control	35·0	40
	Irradiated	49·2	
Liver	Control	17·3	106
	Irradiated	35·6	
Muscles	Control	5·6	
	Irradiated	6·5	16*

* In contrast to all other organs investigated in two subsequent experiments, carbon-14 uptake by muscle tissue was not found to be influenced by irradiation.

The above results indicate that, while the blocking of the formation of nucleoproteins is probably the most conspicuous biochemical effect of X-rays, the total metabolic pattern is influenced as well.

A possible explanation of at least part of the enhanced incorporation of carbon-14 into the tissue of irradiated animals is that in such animals the basal metabolism is slightly decreased. Such a process would lead to a higher activity-level in the organism which, in turn, would cause an increased incorporation of carbon-14 into organic processes.

Gould *et al.*[2] collected labelled carbon dioxide exhaled by full-grown rats following the administration of labelled acetate. During the first hour they found a 50 per cent reduction in the specific activity of carbon dioxide every 15 minutes, and interpreted this observation as being primarily a dilution of isotopic carbon dioxide of the body fluids with non-isotopic carbon dioxide of metabolic processes. In the course of four hours they observed an exhalation of 87 per cent of the carbon-14 administered. Since our experiments lasted about eight hours, and rapidly growing rats and mice were used, we can expect a still larger percentage exhalation to have taken place. In view of the small percentage of carbon-14 incorporated with the tissues, a decrease of 1 per cent only in the amount of exhaled carbon-14 during the experiments can be expected to lead to an increase of 10 per cent, or possibly much more, in the carbon-14 uptake by the tissues. If this interpretation is correct, it should be possible by measuring the increase in the incorporation of carbon-14 in the animal tissue following irradiation or other metabolic interferences to determine small changes produced in the metabolic-rate.

In view of earlier observations, according to which the turnover of liver phosphatides is restricted under the action of X-rays, experiments were carried out on the lines described above, in which 0·05 μ curie of phosphorus-32 was administered to each mouse. No significant difference was found between the phosphorus-32 uptake by the phosphatides of the liver or of the intestinal mucosa of the irradiated mice and that of the controls. Thus, so far the nucleic acids[3] are the only compounds identified, the formation of which takes place at a markedly reduced rate under the effect of X-rays.

My thanks are due to Miss G. Dreyfus for very effective assistance.

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A Sympatholytic (Adrenergic Blocking) Substance (Dibenzyl-β-Chloroethyl Ethyl Ammonium Bromide) with Rapid Action and High Activity in Animal Experiments

The substance N,N-dibenzyl-β-chloroethylamine was synthetized by Eisleb in 1930 [1]. However, its very interesting biological properties were not discovered until 1945 by Nickerson and Goodman[2]. Since then, Nickerson and his associates have published a series of papers on this substance, which has been given the trade mark 'Dibenamine'. The action of 'Dibenamine' mainly consists of an adrenergic block of higher degree and duration than that of any older drug of this type. It has already been widely used in physiological studies concerning the

sympathetic nervous system. Nickerson and Goodman[3] consider that 'Dibenamine' exerts its systemic effect after an intramolecular re-arrangement, forming a highly reactive, cyclic ethylenimonium cation. This procedure, however, takes some time, and thus explains why the substance *in vivo* does not develop its full effect until about thirty minutes after an intravenous injection.

In order to get adrenergic blocking substances of more rapid action, I examined some quaternary compounds of 'Dibenamine', synthetized at my request by L.-O. Plantin, of this Institute. I have not been able to find any reports concerning quaternary compounds of this type except in the form of a short note in a paper of Nickerson, Nomaguchi and Goodman[4], as follows: "Some quaternary derivatives of this series such as dibenzyl-β-chloroethyl methyl ammonium methosulphate are also active". Among quaternary derivatives I have investigated one shows interesting properties, namely, the dibenzyl-β-chloroethyl ethyl ammonium bromide.

After intravenous injections of 5 mgm./kgm. in rabbits and cats (urethane anæsthesia), an immediate and definite fall in blood pressure is observed. Already after 5–10 minutes the substance almost entirely blocks the blood pressure effect of about 1,000 μgm./kgm. of epinephrine, which means a very strong and rapid decrease in epinephrine action. In comparison, 'Dibenamine' in the same amount is unable within this short time to block entirely even the effect of 5–10 μgm. of epinephrine. The duration of the adrenergic blocking effect of this quaternary derivative is as prolonged as that of 'Dibenamine', or many hours.

Studies of the general toxicity of the compound in white mice reveal the following figures for LD_{50} by intraperitoneal injection: 'Dibenamine', 0·15 gm./kgm.; quaternary derivative, 0·04 gm./kgm. The local toxicity, that is, tissue damage owing to the nitrogen mustard-like action (β-chloroethyl group) has not been definitely studied yet; but experiments are proceeding. The question of clinical applicability of this highly active derivative can scarcely be discussed until further investigations now in progress have been completed.

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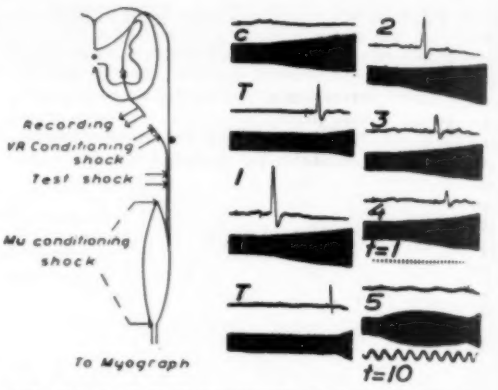
Self-Regulation of the Muscle Contraction by Facilitation and Inhibition from its Proprioceptors

IN order to approach the question raised by the title of this communication, we need a method of testing the excitability of the motoneurones of one muscle, and of that muscle alone, while the muscle itself is contracting or passively stretched. To this end we make use of the properties of the monosynaptic arc analysed by Lloyd[1,2]. (i) A weak electrical test shock (see left half of diagram), set up through electrodes on the nerve of the ankle extensors (cat under 'Dial'), delivers a fast volley through the monosynaptic path in the spinal cord, faster than any other impulses, and this volley can be picked up at



Left half. Diagram of monosynaptic reflex circuit from the ankle flexor afferents to ventral root, which is divided into two portions. Stimulating electrodes on distal stump, recording electrodes on proximal stump. Electrodes for test shock on muscle nerve

Right half: The eight paired records all consist of response from 'recording' electrodes (above) and muscle tension on an isometric myograph (below). Initial tension in all records about 250 gm.; conditioning shock, alone in *C*, adds about 280 gm. *T* (upper), test shock alone. 1–4, both combined at different intervals, measurable on time-scale $t = 1$ (= 1 msec. between marks). *T* (lower) with time-scale ten times as big, $t = 10$. 5, on same scale shows long interval between conditioning shock and test shock

the point marked 'recording' on the central stump of the halved ventral root S_1. The other ventral roots from L_5 backwards have been severed and the leg denervated except for the nerve to the ankle extensors. (ii) The monosynaptic volley traverses fibres which, on the afferent side, originate in, and, on the efferent side, return *to*, the muscle concerned, so that the test shock actually tests the excitability of its motoneurones alone.

This test shock sets up control response *T* on the fast record in the diagram (right half, *T*, upper) for which the speed of sweep of the cathode ray is found from the line $t = 1$ (= 1 msec. between dots). The volley is seen to have needed about 3 msec. from its preceding shock artefact to reach the recording electrodes. Below the response *T* is given a record of the beginning of the muscle contraction which, of course, succeeds *T* and thus cannot influence the testing of the motoneurones by *T* traversing the spinal cord. The muscle can, in addition, be made to contract by administering a preceding conditioning shock *C*, either to the distal stump of the cut ventral root (= *VR*-conditioning shock) or, alternatively, to the muscle itself (= *Mu*-conditioning shock). In the right half of the diagram, *C* shows the muscle contraction, again below the corresponding impulse record, initiated by the *VR*-conditioning shock alone. An *Mu*-conditioning shock would have given similar results. Conditioning shocks must be weak.

The muscle contraction, whether elicited in one way or the other, sets up impulses which modify the excitability of the motoneurones, tested by shock *T*, which in records 1, 2, 3 and 4 is shifted farther away from the conditioning shock that is always placed in the records as in *C*. In 1 there is strong facilitation of *T*. This diminishes in 2. In 3 the test shock is already depressed, and in 4 this depression is still greater. The speed of sweep of the cathode ray is then diminished to $t = 10$ (= 10 msec. between wave tops). A new test shock *T* (bottom record in first row) is first thrown in as control. It is somewhat smaller than the earlier one, and this amount of

natural variation is nearly always present with monosynaptic volleys. Then, in record 5, the test shock is thrown in very late in the contraction set up by the conditioning shock, and is now found to be almost completely inhibited. This transient or phasic inhibition is less prominent with low initial tension of the muscle and becomes very much stronger when the contraction starts from a level of good tension. If the sweep is triggered by merely stretching the muscle quickly instead of stimulating it to contract, the phasic inhibition obtained can be just as complete as that set up by a contraction. Part of the inhibition may be peripheral.

The muscle is thus provided with nervous governors, first facilitating its contraction, then putting on the brakes. At least in some animals, *both* governors may be 'tonic', a fact of great interest for spastic states and the phenomenon of decerebrate rigidity, which hitherto has been interpreted chiefly on the basis of afferent excitation, because adequate methods for the analysis of autogenetic afferent inhibition have not been available. A few references to early important work[3,4,5] may serve to indicate the background.

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Origin and Site of Formation of Fructose in the Fœtal Sheep

Bacon and Bell[1] isolated and identified fructose in fœtal sheep's blood. This was the first conclusive proof of its existence prenatally. They also showed it

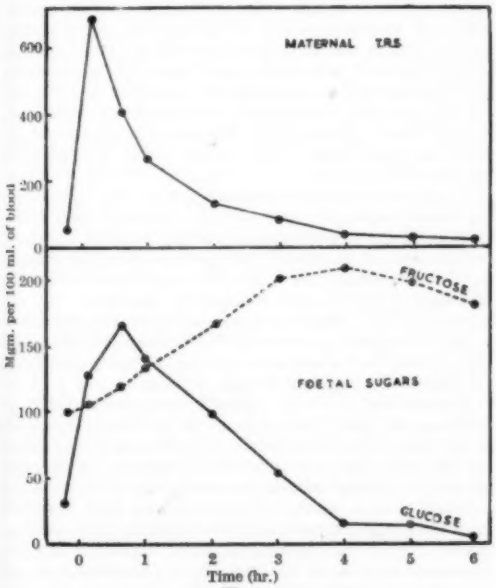

Fig. 1

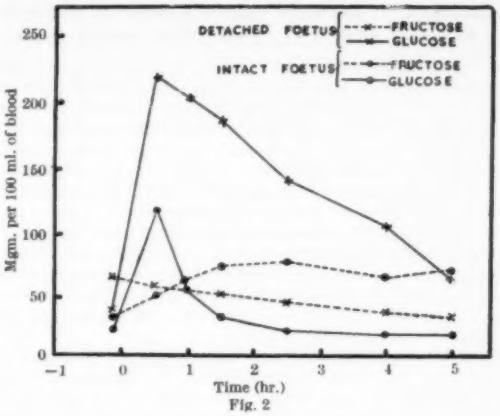

Fig. 2

disappears from the blood of the new-born lamb within three days of birth. During 1948 we performed experiments designed to throw some light on the mode of formation and site of origin of this fructose. Cæsarean section was performed under spinal anæsthetic supplemented by pentothal (which we find to be without effect on the blood sugar). The ewe was immersed in saline at 38° C. into which the fœtus was delivered. Blood samples were taken from the maternal dorsalis pedis artery and the umbilical vein. The total reducing substances and the fructose were estimated by the Somogyi–Nelson[2] method and the Cole[3] modification of the Roe's method respectively. The difference was taken as an approximate measure of the glucose.

Glucose (2 gm. per kgm.) given intravenously to the mother always caused a typical sugar tolerance hyperglycæmia reaching 700 mgm. Accompanying it there was always a parallel but smaller (150–200 mgm.) curve of fœtal hyperglycæmia. In every case there was also a delayed but progressive prolonged fœtal hyperfructosæmia (150–200 mgm.) reaching a maximum in about four hours and then returning to normal after six hours (Fig. 1). The same fœtal hyperfructosæmia was obtained on injection of glucose into the umbilical vein. This phenomenon was got with fœtuses of all ages from ninety days onwards, the youngest age examined.

If the fœtus was detached (being viable) from the placenta 7–10 min. after the umbilical vein was injected with glucose, the rising blood fructose was terminated. This experiment has been performed both on a single fœtus and also with twins, both being injected, the attached one serving as a control to the detached (Fig. 2).

It would appear, therefore, that glucose entering the pl centa, whether from the maternal or fœtal circulation, can lead to the formation of fructose, and that this does not occur elsewhere in the fœtal tissues.

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Changes in Serum-Protein Levels in Rabbits Treated with 1:2:5:6 Dibenzanthracene

NUMEROUS attempts have been made to demonstrate specific changes in blood proteins in direct relation to malignancy. For a summary of the literature on this subject, the reader is referred to the work of Stern and Wilheim[1], and to the more recent article by A. B. Gutman[2]. Most of these studies have been made on animal and clinical material with a fully developed picture of malignancy.

In a research designed to investigate the nature of the changes in blood proteins in malignancy, we have conducted a series of preliminary studies, the object of which was to follow any deviation in serum-protein levels from the normal through the precancerous state to final malignancy.

Adult male rabbits were employed as experimental animals, using the carcinogen 1 : 2 : 5 : 6 dibenzanthracene. The investigations extended over a period of six months, when they were terminated owing to the death of three of the eight treated animals; four animals were maintained in the control series. Blood was obtained by simple venipuncture of the ear, and weekly determinations were made of the total serum proteins, total albumin and total globulin, employing the biuret reaction[3]; body-weights of both the control and treated animals were also determined at weekly intervals for the entire period of the experiment.

After determining the serum-protein levels for one month to obtain the normal level for each animal, 200 mgm. of 1 : 2 : 5 : 6 dibenzanthracene, contained in a gelatine capsule, were surgically implanted into the abdominal wall of each of the eight experimental animals. At the end of six months, all the surviving animals were sacrificed and necropsies performed. Three animals were found to have bile duct carcinomas, a fourth a carcinoma of the lung, and a fifth a spindle cell sarcoma at the site of implantation of the dibenzanthracene. The remaining three experimental rabbits were free from malignancy, and appeared to have no liver involvement.

Determinations of the total serum proteins showed no significant differences in levels between the treated and control series. With the exception of one animal suffering from a tumour of the liver, and showing a lowered serum albumin content, no differences were also observed in the levels of the albumin fraction. However, in the case of the serum globulin this was found to be significantly increased in all animals with liver tumours; there was no increase in this fraction in any of the other tumour-bearing animals; experimental animals which did not develop tumours showed no significant differences in any of the protein determinations made.

From the experimental data so far available, it would appear that 1 : 2 : 5 : 6 dibenzanthracene does not produce a significant change in the levels of any of the protein fractions so far examined, with the exception of animals that develop tumours of the liver, when there is a rise in the globulin fraction. We conclude, therefore, that if any change does occur, it does so within one or more of the individual fractions of these proteins; these possibilities are being investigated at the present time, and preliminary results on animals treated with 20-methyl cholanthrene sixteen weeks ago, and now presumably in a precancerous state, suggest an increase in the protein fraction precipitated by 25 per cent saturation with ammonium sulphate, and a further increase in the fraction not precipitated by 70 per cent saturation with ammonium sulphate, but precipitated by 10 per cent trichloracetic acid; whether or not these changes will continue and persist in malignancy remains to be determined.

Our thanks are due to Mr. J. H. Thompson, director of research at these Laboratories, to Dr. G. J. W. Ollerenshaw for the surgical implantation of the dibenzanthracene, and to Dr. R. Fleming for the preparation of numerous sections.

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Drug Action of Formaldehyde Derivatives of Sulphathiazole

THE present-day concept of effective sulphonamide therapy is based on experimental evidence which conditions high concentration in extracellular fluid and a minimum of localization in tissue cells as essential desiderata for successful drug action. Our experiments with the formaldehyde derivatives of 2-sulphanilamidothiazole, against a Gram-positive coccus (*Streptococcus pyogenes*), a Gram-negative bacillus (*Salmonella typhi*) and a vibrio (*Vibrio choleræ*) indicate an essentially different mechanism of drug action.

In a previous communication[1] reference was made to (1) the preparation by one of us (S. S. B.) of compounds by hexamethylene-tetra-amine linkage to *p*-aminobenzene-sulphanilamide, and (2) the condensation of formaldehyde with sulphathiazole by Meier[2] and Druey[3], which, in our hands, proved to be an effective antidote for the prevention and treatment of Asiatic cholera[4]. Further studies on experimental infections with the typhoid bacillus and the streptococcus presented the puzzling observation that potent chemotherapeutic activity went along with a peculiarly prolonged low blood concentration, a fact which did not fit in with the accepted concept of 7–10 mgm. per cent blood value for effective therapeutic action.

Since formosulphathiazole is only slightly soluble in water and common organic solvents, its therapeutically active sodium salt was prepared by interaction with sodium carbonate, which gave an alkaline product reacting in the N-1 position with the hydrogen of different sulphamyl groups. At the same time this reaction indicated that the condensaton of formaldehyde with sulphathiazole takes place on a 3 mol. : 3 mol. basis, giving rise to a compound of unusually high molecular weight.

Metabolism of the parent compound and its sodium salt was studied in mice, guinea pigs, rabbits and dogs by colorimetric determination of blood values, urinary excretion and tissue concentration, in terms of sulphathiazole standards, by a modified method which combined the Bratton and Marshall[5] and Druey and Oesterheld[6] techniques. The plasma-water concentration ranged only between 1–2 mgm. per cent in spite of the maximum tolerated dose and parenteral route employed. This was also the case

with human beings after 8 gm. of the sodium salt in 24 hours, the blood values being still lower. With formosulphathiazole the low value was maintained almost at the same level from thirty-six to forty-eight hours; with the sodium salt there was an initial rise and a subsequent detectable fall in twenty-four hours. Binding on to plasma proteins could not be determined on account of blank results after boiling for only thirty minutes, indicating a chemical change, different from acetylation of N^4 nitrogen, in passing through the body.

In contrast to the low blood values, which gave no indication of absorption of the two compounds, urinary excretion was well marked and rapid. It reflected the greater absorbability of the sodium salt by maximal initial excretion, both comparative and absolute, followed by gradual fall. In animals as well as in human beings, with 250 mgm. of the salt, 140–150 mgm. per cent of the drug could be detected in the urine within thirty minutes, especially if it had been administered subcutaneously. Formosulphathiazole, on the contrary, gave initial low urine values increasing with the course of time. Excretion went on for seven to eight days, especially in rabbits.

Tissue distribution in liver, spleen, lung, brain and muscle was studied over periods of ½, 1, 2, 4, 8 and 24 hr. with 0·5, 1·0 and 2·0 gm. per kilo weight dosage under natural conditions and by Fisher's technique[7]. It was markedly in contrast to other sulpha derivatives in that the tissue concentration to plasma-water concentration ratio was two to four times higher in the case of formo compounds, strongly indicating their localization in tissue cells. No significant change took place either in the tissue or plasma–water concentration after tying the renal blood vessels. As compared with other tissues, in which the drug was well distributed, a special affinity for liver and spleen was apparent with higher doses of the sodium salt, an increase of four to five times in concentration being observed even after half an hour. This was not the case with formosulphathiazole, in spite of massive doses by oral and parenteral routes. Cerebrospinal fluid showed the presence of the drug in animals and human beings.

Before administration, formaldehyde was detectable in both formosulphathiazole and its sodium salt in as high a dilution as 1 : 10,000. After so short a period as fifteen minutes after administration, we were unable to detect it in the animal body, in blood, urine or tissues, by most of the methods recommended. Nevertheless, the important role of the formaldehyde content of these compounds was evident (*a*) from potent endotoxin neutralization in *in vivo* experiments, when 50 mgm. of formosulphathiazole or 20 mgm. of its sodium salt resulted in 100 per cent survival against 100 per cent mortality in control mice given $20{,}000 \times 10^6$ killed typhoid bacterial cells, and (*b*) from striking improvement in the results of clinical trials when we employed the optimal *p*H conditions under which formaldehyde is known to modify diphtheria toxin to toxoid[8]. The latter effect was achieved by alkalizing the patients so that the *p*H of their urine remained between 8 and 8·6 during the treatment of their bacterial infection (typhoid fever) or virus infection (smallpox, influenza and parotitis).

From the experimental data presented here, it is concluded that: (1) the chemotherapeutic activity of the formaldehyde derivatives of sulphathiazole is related to their property of tissue localization, especially in organs rich in reticulo-endothelial cells, rather than to their concentration in extracellular fluid; and (2) their formaldehyde content (11–11·2 per cent)[9] plays an essential part, most probably on account of the well-known versatility of its reactions with the amino-acids of human tissues and those of the exo- and endo-toxins of diverse bacterial species and viruses.

Taking into consideration the results of clinical trials, very briefly indicated here, the possibility is envisaged of wider application of formaldehyde condensation products to those infectious diseases in which the study of host-parasite relationships is indicative of intracellular localization.

Detailed investigations are being published elsewhere.

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Molybdenum and Sulphur in Symbiotic Nitrogen Fixation

Nitrate accumulation due to ineffective nitrate utilization may occur in plants in cases of deficiencies of either molybdenum[1–3] or of sulphur[4,5]. Though high in nitrogen, such affected plants show symptoms of nitrogen deficiency. It has also been suggested that the effect of molybdenum on legumes is due to its influence in the actual process of symbiotic nitrogen fixation rather than on nitrate utilization[6], and that sulphur may indirectly affect legumes through its direct effect upon the nitrogen-fixing organisms[7].

We have examined and compared the roles of molybdenum and sulphur in nitrogen metabolism following the identification of a severe triple deficiency of sulphur, molybdenum and nitrogen on certain soils on the Southern Tablelands of New South Wales. On nitrogen-deficient soils, nodulated plants of subterranean clover (*Trifolium subterraneum* L.) deficient in either sulphur or molybdenum grew poorly and showed typical symptoms of nitrogen deficiency. These plants were, in fact, very low in percentage total nitrogen in contrast with the dark green, well-developed plants provided with both elements.

Molybdenum-deficient legumes were provided with nitrate nitrogen without any accompanying increase in the soil *p*H by using nitric acid as a source of nitrogen. This greatly reduced the uptake of molybdenum by the plants; yet clovers responded markedly in colour and growth to the nitrate nitrogen, and the treated plants did not then respond to molybdenum. Only the clovers not treated with combined nitrogen responded to molybdenum. Greening and stimulation of growth due to the addition of nitric acid or ammonium sulphate occurred even in the very early stages, while the response to molybdenum alone did not appear until nodulation was well established. It

is clear that the added molybdenum was not needed by the host legume for the utilization of nitrate nitrogen, but was required in the actual process of symbiotic nitrogen fixation.

Non-legumes, in parallel experiments on these soils, did not respond to molybdenum even when provided with nitrate nitrogen. The small amount of available molybdenum in the untreated soil was ample for plant metabolism in both legumes and non-legumes, but was inadequate for symbiotic nitrogen fixation. Only when the uptake of soil molybdenum was greatly reduced by treatment with manganese sulphate in addition to ammonium sulphate or nitric acid was response of a non-legume to applied molybdenum obtained. Where nitric acid was the source of nitrogen, marked nitrate accumulation occurred in the molybdenum-deficient plants.

On nitrogen-deficient soil, clovers deficient in sulphur, like those deficient in molybdenum, grew poorly and contained a low percentage nitrogen, but, in contrast, responded little to added nitrogen. This indicates that the increase in symbiotic nitrogen fixation following treatment with sulphates was due to the effect of the sulphur on nitrogen metabolism within the plant. Sulphur-deficient plants treated with nitrate nitrogen showed typical symptoms of nitrogen deficiency; but frequently contained a higher percentage total nitrogen than did corresponding sulphate-treated plants. They showed the characteristic symptoms of a high percentage of non-protein nitrogen with accompanying nitrate accumulation, and a low percentage of protein nitrogen.

The effects of sulphur on nodulation further support the above interpretation of its role in symbiotic nitrogen fixation. Sulphur deficiency, like added combined nitrogen, decreased the number or size of nodules. It affected nodulation most in the presence of combined nitrogen, or in the presence of molybdenum. This contrasts with the effect of molybdenum, which exerts its influence in the actual process of nitrogen fixation. Clovers deficient in molybdenum for symbiotic nitrogen fixation are better nodulated than the treated plants[6].

The evidence shows that either molybdenum or sulphur deficiency will inhibit symbiotic nitrogen fixation and reduce the yield and nitrogen content of legumes. Molybdenum has a dual role. Very minute quantities are required to permit nitrate utilization in plants. Appreciably greater quantities are needed by legumes in the symbiotic nitrogen fixation process, either in the initial reaction with gaseous nitrogen or in a later reaction which is not an essential step in either nitrate or ammonia utilization. In contrast, we found no evidence that sulphur exerts its influence in the actual process of symbiotic nitrogen fixation. It appears to increase symbiotic nitrogen fixation primarily through its effect on nitrogen metabolism within the plant.

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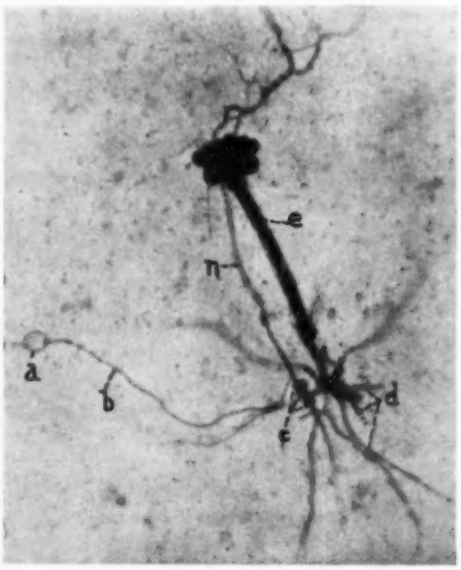
Association of *Gonatorrhodiella Highlei* with *Nectria* Species

During 1947, *Gonatorrhodiella Highlei* A.L.Sm., a member of the Fungi Imperfecti only once recorded in Great Britain before[1], was observed forming yellowish felts of conidiophores on the bark surfaces of stored beech and poplar logs at the Royal Botanic Garden, Edinburgh.

The fungus has been known in connexion with beech bark disease[2,3] in Canada and the United States since 1929 as an associate of *Nectria coccinea* var. *faginata* Lohman, Watson and Ayers, a fungus which gains entry through injury caused to the bark by the beech scale, *Cryptococcus fagi* Baer. *G. Highlei* has been regarded as a parasite; but no direct evidence to support this view has been published. Researches conducted in Edinburgh have established the following points:

(1) On the beech, *G. Highlei* developed within the perithecial stromata of *Nectria cinnabarina* (Tode) Fr., a new host fungus.

(2) On the poplar, the fungus spored freely from bark which yielded a further *Nectria* sp., agreeing with varieties of *N. coccinea* in having a *Cylindrocarpon* stage.



Photograph showing association between *G. Highlei* and a *Nectria* species. *Gonatorrhodiella*: *a*, conidium; *b*, germ tube; *c*, hook cells; *d*, branch hyphæ; *e*, conidiophore. *Nectria*: *n*, parasitized hypha

(3) In cultures from mixed conidial suspensions of the latter *Nectria* sp. and *G. Highlei* plated on either *Nectria*-, or *Trichothecium*-, or *Trichoderma*-extract agars, direct evidence of parasitism was obtained. The germ tube, 2–3 μ in width, produced on germination of a *Gonatorrhodiella* conidium makes contact with a *Nectria* hypha by means of an appressorium, from which unicellular hooks are formed to encircle the hypha. Dilated branch hyphæ, 5–7 μ in width, are then given off from the periphery of the appressorium and occasionally from the lateral walls of the hook cells. These hyphal branches also effect contact with other *Nectria* hyphæ after undergoing a

period of growth. Conidiophores of *G. Highlei* are given off from the branch hyphæ after some four weeks in culture. As the effect of parasitism on the *Nectria* hyphæ is negligible, it is considered to be of a much controlled form.

(4) On extract agars, intrahyphal growths occur within the lower conidiophore cells, and under natural conditions play a part in conidiophore proliferation.

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Death of Sycamore Trees Associated with an Unidentified Fungus

An unusual disease of sycamore (*Acer pseudoplatanus* L.) has been under observation in south-west Essex since autumn of 1945 [1]. The disease, which is believed to be unrecorded hitherto, is associated with a peculiar unidentified fungus.

The first obvious symptoms are dark, vertical lesions on the trunk or branches, where the outer layer of bark has peeled off, exposing a mass of brownish-black powdery spores. Often large areas of apparently normal bark can be peeled off, exposing a thick layer of the spores, which have been produced from a stroma within the bark (see photograph). In later stages the tree is girdled and killed. When the bark has been shed, these dead trees are conspicuous by their dark, velvety appearance, and by the copious deposit of spores blackening the surrounding vegetation. The wood beneath young lesions is stained yellow-brown; but when the tree is dead the wood is light in colour and dry. Although proof of pathogenicity is as yet lacking, there is strong circumstantial evidence that the associated fungus is an active parasite, capable of attacking and killing sycamores of all ages.

The staining travels up and down the trees, well beyond the external limits of the lesions and sometimes for the whole height of the trunk and main limbs. Most of the lesions appear to be formed at points where the staining extends to the cambium rather than by infection from without, and incipient lesions have been found where the cambium and inner bark were already dead, while the outer bark was still alive. The assumption is therefore that once the tree is infected the fungus travels up and down in the vessels, producing fresh lesions whenever it comes into contact with cambium. There is thus a strong resemblance between this disease and canker stain of plane trees (*Plantanus*)[2] and sapstreak of sugar maple[3] in the United States; both these diseases are associated with fungi of the genus *Endoconidiophora*.

With the sycamore disease, when the outer bark is peeled off, both the inner and outer portions are found to be covered by a thin plectenchymatous stroma. The inner stroma bears a closely packed hymenium of short phialides. The brown, unicellular, smooth, spherical-to-oval spores, 3 μ × 2 μ, are formed in fragile chains. The inner and outer stromatic layers are connected by plectenchymatous columns. These columns may be seen as a close layer of fine projections on the bark when the spores filling the interstices have blown away. Spore production is of the order of 10^7 per sq. cm. The occurrence of other stages in the life-cycle of the fungus is suspected but not yet proved. The organism has been observed only on sycamore; but there has so far been no opportunity to examine other species of *Acer* or *Platanus* in the proximity of affected sycamores.

Investigation in the locality is being continued. The fungus appears to be a destructive parasite of the sycamore, and must be regarded as a pathogen of the first importance. From a single diseased tree seen in 1945 the disease has now spread over a mixed woodland area of about seventy acres, where more than a hundred sycamore trees are affected. As a precaution these have been felled and burned.

The object of this preliminary report is to stimulate search for this disease in other areas. We should be glad of further information on its distribution.

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Fluorescence of Soil Constituents in Ultra-violet Light

The only record of which I am aware of the use of the screened ultra-violet lamp for the detection of soil constituents is by H. L. Richardson[1]. Richardson examined air-dried samples from a very comprehensive collection of soil profiles. He noted that soils rich in organic matter displayed a uniform coffee-brown or even blackish colour. A distinct fluorescence

was observed in soils which were heavily impregnated with salts, while a dull fluorescence was observed where gleying had occurred. He noted that non-suberized rootlets fluoresced brightly, and it was suggested that screened ultra-violet light might prove serviceable in studies of root distribution.

I have examined a variety of Irish soils using a 125-watt Osira 'black glass' lamp. In the case of air-dried samples which, however, included no saline soils, the general results were in conformity with those observed by Richardson. While the method as directly applied would thus seem to be strictly limited in scope, there is evidence of possibilities in its application to the study of soil fauna where freshly sampled material is concerned. The fluorescence of several organisms was noted; for example, the earthworm showed a bright white fluorescence, the source of which was found to be located at the lines of pores between the segments.

In contrast with the comparatively meagre fluorescent effects displayed by ordinary soils, it was found that simple extractive methods reveal the presence in all soils of at least two organic substances which display strong fluorescence when in solution. One of these, which shows a bluish-white fluorescence, is wax-like in character; the other, which has a yellow fluorescence, is intimately associated with the brown colloidal material which is regarded as the ultimate stage of humification.

Organic solvents such as alcohol, ether, chloroform or benzene readily extract the former. When equal quantities of air-dried samples from a variety of profiles were extracted with ethyl alcohol, there was considerable variation in the intensity of fluorescence of the extracts, the result, as a rule, being roughly proportional to the total quantity of organic matter in the samples. For example, extracts from the lower horizons of gley soils were invariably less fluorescent than those from the top horizons. The extract obtained from air-dried peat with alcohol also displays a strong bluish-white fluorescence. This white fluorescence in all cases is sharply diminished on the addition of a small amount of mineral acid.

In the case of some soils, notably one derived from Silurian strata, and some derived from Carboniferous limestone intermingled with volcanic trap, the intrusion of which was contemporaneous with the deposition of the limestone, the fluorescence displayed in extracts with organic solvents was of a purplish colour, a fact which might suggest the presence of a red component. Evaporation of the extracts obtained from all soils with pure organic solvents yielded a yellowish-white residue which in the solid state had a pale white fluorescence.

It would seem likely that the fluorescence of soil extracts obtained with pure organic solvents is attributable to a substance similar to the montana wax obtainable from peat. A sample of crude peat-wax prepared by Soxhlet extraction of air-dried peat with acetone continued to show fluorescence in alcohol at a dilution of 1 : 500,000.

While the fluorescence of this presumably wax-like material in soils is readily detectable in an extract even when irradiated through the wall of an ordinary glass test-tube, it is best demonstrated by placing a gram or so of the soil in the centre of a flat sheet of filter paper and adding the solvent to the soil sample drop by drop. The circle of liquid which gradually spreads out on the paper fluoresces with distinctive brightness. There is a diminution in intensity as the liquid evaporates, the final zone of fluorescence being chiefly concentrated in the outer ring. Little or no fluorescence is to be observed against the background of soil. White porous earthenware may be used instead of filter paper; but in this case the fluorescence is considerably less pronounced. Alternatively, if a small quantity of the soil be placed on top of a column of kaolin in a thin glass tube and the solvent be poured through, a very strong fluorescence becomes visible in the kaolin layer while virtually none is apparent in the soil.

As distinct from the white fluorescence displayed when the soil is extracted with pure organic solvents, it has been observed that while the brown colloidal soil constituent variously known as humus or as 'humic acid' is coloured brown in the solid form in screened ultra-violet radiation, its solutions are a deep olive-green, the meniscus displaying a yellow fluorescence. This complex substance dissolves from all soils in aqueous alkali solutions. It is also partially soluble in alcohol in presence of an acid such as hydrochloric.

I have shown[2] that when the brown colloidal humic material which accumulates in the *B* horizon of podsols has been isolated from the sesquioxides on which it has precipitated in the profile, it is readily soluble in both pure water and in alcohol. This humic material, when in dilute solution, displays in ultra-violet light a strong golden-yellow fluorescence which is still detectable with the Osira lamp at a concentration as low as 1 : 10^6. Its fluorescence is somewhat stronger in alcoholic solution than in water. Unlike the bluish-white fluorescence previously dealt with, the yellow colour associated with humus is uninfluenced by the presence of acid. An alcohol-soluble fraction of humus prepared from peat shows a fluorescence behaviour identical with that of the humus obtained from the podsol *B* horizon.

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Control of a Beam of Electrons by an Intersecting Electron Beam

If an electron is sent across a beam of electrons the chance is very small that it will pass a single electron of the beam so closely as to cause any deflexion of consequence from its original path. In a beam that has a current-density of 100 mA./cm.^{2} and a velocity of 100 electron-volts, the electron density is such that it contains 10^8 electrons per cm.^{3}. So the mean distance between two neighbouring electrons may be said to be about 10^{-3} cm. To obtain a deflexion of 1°, however, a crossing electron would have to pass an electron of the beam at a distance of about 10^{-7} cm.

It is, nevertheless, possible to control an electron stream by an intersecting beam. The charge of the latter can lower considerably the potential in the space where actual crossing occurs, and the passage of the former stream can be entirely prohibited by this potential barrier.

Fig. 1 shows a cross-section of an electron tube in which this was realized. One of the concave cylindrical sides of an oblong cathode C_1 ($V = 0$) is oxide-

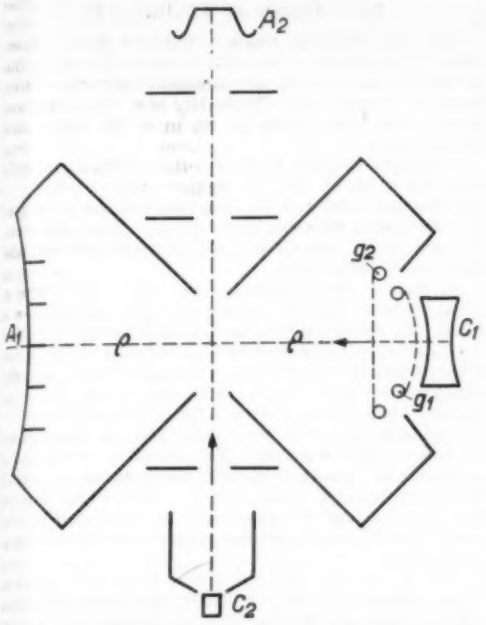

Fig. 1. Cross-section of an electron tube in which an electron stream from C_1 is controlled by a crossing beam from C_2

coated. With the aid of a concave control grid g_1 and a flat screen grid g_2 ($V = 100$ V.), a converging ribbon-shaped beam is sent into a room, the conducting walls of which are connected to the screen grid. At the opposite side of the room an anode A_1 is connected to the walls. Intermediate between screen grid and anode the room has a narrower part. The edges of the projecting parts of the wall have slits through which another ribbon-shaped electron beam, slower and carrying less current, enters the room, and leaves it again after crossing the first beam. The second beam emerges from cathode C_2 ($V = 84$ V.) and runs to anode A_2. To prevent this second beam from reaching A_2, the potential of the space where crossing occurs has to be lowered 16 V. by the space charge of the first beam. A current of 10 m.amp. in this beam appeared to be sufficient in our case. The potential in the room is lowest in the vicinity of the points ρ, as here the distance to the walls is greatest. Consequently the space charge of beam 1 at the same time controls and concentrates beam 2. Hence a small variation of potential is sufficient to control the current to anode 2. If at the point of crossing the potential is a minimum, beam 2 would be more and more dispersed as this potential minimum is lowered, and, as our former experiments showed, much larger potential variations would be necessary to control anode current 2. Beam 1, and consequently also anode current 2, are controlled by the voltage of grid 1.

In Fig. 2 a characteristic curve $I_{a_2} = f(V_{g_1})$ is shown. The maximum value of $\frac{dI_{a_2}}{dV_{g_1}} \Big/ I_{a_2}$ is 23 volt^{-1} in this case. This is more than twice the value which can be obtained with normal grid control because of the energy distribution of the electrons. It would be possible to obtain even higher figures. If, instead of A_2, a secondary emission multiplier be employed, slopes of several amperes per volt can be attained at anode currents in the order of 10^{-2} amp.

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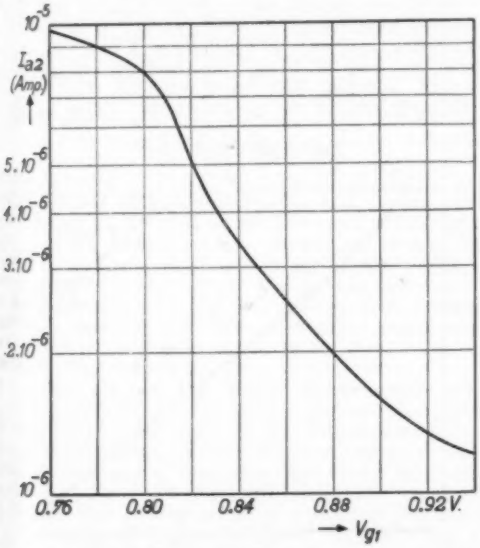


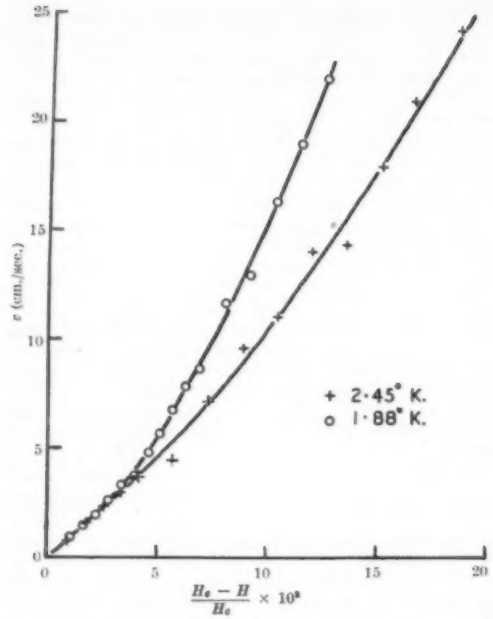
Fig. 2. Relation between current to anode of second beam and control grid voltage of first beam. The current contains a constant portion of 10^{-6} amp. due to leak, stray electrons, etc.

Creation and Growth of Superconducting Nuclei

A superconductor in its normal state in a magnetic field can be 'supercooled', in the sense that the field must be decreased some way below its critical value H_c before the transition into the superconducting state occurs. The explanation of this, originally given by London[1], is that a boundary between the two phases has a surface energy, which makes the creation of the first nucleus of the superconducting phase energetically difficult.

It has been found possible to create a nucleus artificially in supercooled tin by reducing the field locally, and the superconducting phase then spreads through the specimen. Using a long cylindrical rod (length 18 cm., radius 1·5 mm.) in a longitudinal field, the movement of the phase boundary has been followed by means of coaxial search coils connected to a ballistic galvanometer. The method is analogous to the well-known experiment of Sixtus and Tonks in ferromagnetism[2]. The boundary appears to travel in a regular and reproducible manner; rates of travel (v) have been measured, which are plotted against the relative supercooling, $(H_c - H)/H_c$, for two different temperatures, in the accompanying graph.

The observed behaviour can be understood qualitatively if eddy currents are the principal factor controlling the rate of travel. The lines of force of the magnetic field are pushed out of the specimen



as the superconducting region expands. This sets up eddy currents in the normal tin, which increase the field at the phase boundary : it is the condition that the field at the boundary should not exceed H_c which limits the rate of expansion. A simple calculation shows that a thread-like superconducting nucleus along the axis of this specimen, growing radially, will take about 3 sec. to reach the edge, when $(H_c-H)/H_c = 0{\cdot}01$; this is not inconsistent with the experimental observations. The more difficult problem of growth along the rod involves a consideration of the demagnetization energy of the superconducting region and its surface energy, while latent heat may also play a part. A fuller discussion is deferred until more experimental evidence is available.

Measurements on the maximum supercooling attainable before the transition occurs spontaneously are also of interest. This is found to be very much less for the specimen as a whole when the main field is lowered than for parts of the specimen when the field is lowered locally only. It has been shown that, though the maximum relative supercooling for the middle parts of the specimen varies from 10 per cent to 15 per cent, there are regions near both ends which will only supercool by about 3 per cent. This may be due to inhomogeneities near the ends, or to some genuine end effect. The maximum supercoolings found in any one experiment are very reproducible ; but they are not entirely reproduced in different experiments between which the specimen has been warmed to room temperature. The temperature variation of the maximum relative supercooling has not yet been fully investigated, but it appears to increase slightly as the temperature increases.

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Beta Decay of Thulium-170

We have recently made a detailed study of the beta disintegration of 127-day thulium-170, and have obtained results which are in general agreement with those of Saxon and Richards[1], but which do not agree with those recently reported by Grant and Richmond[2].

A sample of pure thulium oxide (Tm_2O_3), kindly supplied to us by Prof. S. Sugden, was irradiated in the Harwell pile, and the activity studied by means of a thick-lens beta-ray spectrometer (to be described by one of us elsewhere), and by coincidence and absorption techniques.

A Fermi plot derived from the spectrometer measurements on the continuous beta spectrum, and from the exact calculation of the Fermi function without screening correction, is shown in Fig. 1. A thin source (0·5 mgm./cm.^{2}) mounted on a 'Zapon' lacquer film (0·1 mgm./cm.^{2}) was used, and the measurements were corrected for the finite resolution of the instrument (3 per cent), and for absorption in the counter window. The linearity of the plot indicates the presence of only one beta-ray group of maximum energy 970 $\pm$ 5 keV. The slight rise at low energies can be attributed to scattering in the source, and possibly to the neglect of the screening correction.

The *K*-, *L*,- *M*- and *N*-internal conversion lines of a gamma-ray of energy 82·7 keV. have been detected, using a counter with a 'Zapon' lacquer window of thickness 0·4 mgm./cm.^{2}. This thickness was sufficient to cause considerable attenuation of the *K* line. As a result of careful search for other conversion lines, it was concluded that no other gamma-rays, such as those reported by Grant and Richmond, occur with intensities greater than 1 per cent of the total disintegration rate.

The electromagnetic radiations were studied by means of the photo-electron spectra emitted by tin and lead radiators. Fig. 2 shows the spectrum obtained in the latter case, and gives further evidence of the 83 keV. gamma-ray, together with the *K* X-ray series of ytterbium-170, which is excited in the *K*-conversion process. A continuous X-ray spectrum with the lead *K* X-ray lines superposed is also present, and has been interpreted as due to the *Bremsstrahlung* of the beta-particles. This experi-

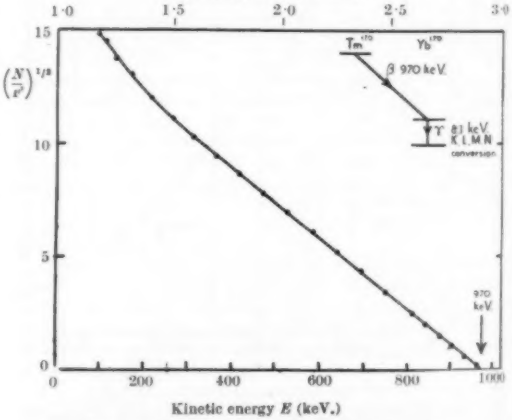

Fig. 1. Fermi plot of the thulium-170 β-spectrum

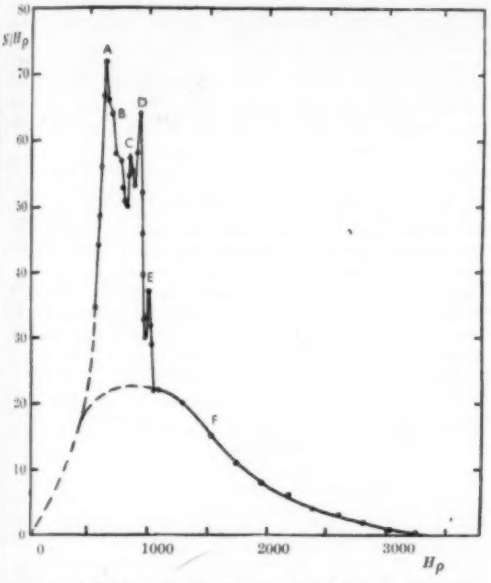

Fig. 2. Spectrum of photoelectrons ejected from a lead foil by the radiations from thulium-170. (*A*) and (*B*), *L*- and *M*-lines of the *K* X-ray series of Yb^{170}; (*C*) *L*-line of the *K* X-ray series of Pb; (*D*) and (*E*), *L*- and *M*-lines of the 83-keV. gamma-ray; (*F*), continuous *Bremsstrahlung*

ment confirmed that no other gamma-rays with intensities greater than 1 per cent of the disintegration-rate are involved.

The following correlations were observed and studied in the coincidence experiments: $(\beta-e_L^-)$, $(\beta-L$ X-ray) and $(\beta-\gamma+K$ X-ray). The ratio $N(\beta-e_L^-)/N_\beta$ was found to be independent of absorber thickness in coincidence absorption measurements, indicating that the 83 keV. gamma-ray transition follows the single beta-ray group, as shown in the proposed decay scheme in Fig. 1. Measurements with variable resolving time showed that the life-time of the transition is less than 10^{-7} sec. A weak $(\gamma-\gamma)$ coincidence effect was detected, and interpreted as a gamma-ray – *Bremsstrahlung* correlation.

Absorption curves of the electromagnetic radiations in aluminium, tin and lead show components attributable to the ytterbium *K* X-ray (~ 50 keV.), the unconverted 83 keV. gamma-ray, and a weak component of higher energy (400–500 keV.). The intensity of this component was about 2 per cent of the total; and this, together with the apparent energy, was found to vary with the atomic number of the material in which the beta-particles were stopped. It was therefore concluded that this represented the continuous *Bremsstrahlung* rather than a nuclear gamma-ray transition.

All the experimental results are consistent with the simple decay scheme shown inset in Fig. 1. The *L* conversion coefficient, α_L, of the gamma-ray has been determined by measurement of the area under the *L* conversion line, and also from the ratio $N(\beta-e_L^-)/N_\beta$ given by the coincidence measurements. The corresponding *K* coefficient has been estimated from the intensities of the ytterbium *K* X-rays and of the unconverted gamma-rays. The values obtained are, $\alpha_K = 40$ per cent, $\alpha_L = 20$ per cent, which are in reasonable agreement with the theoretical results for an electric quadrupole transition.

It is our intention to publish a more detailed account of this work at a later date.

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Cosmical Zero, and the Origin of Radiation and Dense Matter

This communication is prompted by Prof. J. B. S. Haldane's article "A Quantum Theory of the Origin of the Solar System"[1], in which he elaborated some interesting deductions implicit in Prof. E. A. Milne's kinematic relativity. The gist of the argument is that by extrapolation backwards from the observed expansion of the universe (which is assumed to be linear) a zero point is reached at which the universe, and therefore its material contents, had but infinitesimal dimensions; by extrapolation backwards from the known degradation of energy, that is, the increase of wave-length and reduction of energy of radiation with the forward progress of time, a zero point is reached at which photons were of infinite energy, with infinitesimal wave-length to allow them to be encompassed within the bounds of the micro-universe. Such a giant photon in collision with a pygmy sun could, it is argued, account for the origin of the solar system. The fallacy of the argument lies in the assumption that the zero points reached by these otherwise independent lines of extrapolation coincide. There are reasons for believing that this cannot be the case, and indeed for thinking that this identification of two quite separate epochs in cosmic history is an assumption which is at variance with the fundamental laws of entropy.

It is a principle of thermodynamics that with the forward progress of time there occurs a levelling of all irregularities of energy potential, which ultimately become smoothed out to a dead level uniformity; extrapolation backwards leads to a thermodynamic zero hour at which disparities of energy potential were, if not infinite, certainly maximal. All energy at that epoch was confined within atomic nuclei and other primary particles uniformly dispersed through the primeval chaos at a temperature of absolute zero, held frozen in space without motion either of gravitational translation or thermal oscillation: any decession from these conditions implies a previous state of yet lower entropy toward which further extrapolation must be pushed. Such a universe must of necessity have been timeless, since there was no conceivable method of measuring time; as expansion is essentially a function in time, the universe could not have been expanding at that epoch.

If all the energy in the universe were contained within the primary particles at this stage, and there were no photons of radiation, the end result of adiabatic condensation, if uncomplicated by nuclear reactions, would be dense matter, such as is known to exist in certain stars; such dense matter would probably be unstable because of the greatly increased chance of nuclear collisions. The probability of

collision is nil in the original state of the universe, but increases rapidly with condensation. It is therefore suggested that the beginning of the expansion of the universe should be placed at the beginning of the process of galactic condensation, and that it was separated from the first creation of photons by the time necessary for individual star formation. It is unlikely, therefore, that the conditions stipulated by Prof. Haldane for the origin of the solar system could actually have existed, as such a theory is difficult to reconcile with the second law of thermodynamics.

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[1] *Nature*, **155**, 133 (1945).

Solar Flares and the Zeeman Effect

In *Nature* of May 14, Ellison[1] proposes the Stark effect in preference to the Zeeman effect as the cause of the line-broadening observed in the spectra of solar flares. However, Ellison has himself recorded[2], in relation to the observed broadening of the $H\alpha$ line, that "$H\beta$, $H\gamma$, etc., show lesser widths, but the data are very meagre". This is the reverse of what is to be expected on the basis of the Stark effect; but is to be expected if, as I have suggested[3], the broadening is due to Zeeman effect.

The conclusion that the spectra of flares should show Zeeman effects of just the magnitudes actually observed was, in fact, reached as a consequence of the evaluation of the currents in these electrical discharges, based on reasonable extrapolations for the parameters involved from those observed in laboratory discharges[4]. These currents are of the order of 10^{-4} amp., and will give rise to magnetic fields of the order of 10^3 gauss, at the surface of the discharge channels, and hence to splitting of the $H\alpha$ line of about $\pm$ 5 A. Since, however, the magnetic field will vary from zero at the centre of the discharge channel to this maximum value at the periphery, the resultant effect will be a general broadening of the line of the amount actually observed[2].

This conclusion as to the relative magnitudes of the Stark and Zeeman effects apparently received confirmation from an examination of the spectra of *Be*-type stars. If these, as on the discharge view[5], also result from huge electrical discharges, one would naturally look there for further evidence. In the data published by R. H. Curtiss[6] on the spectra of these stars, there appears to be a gradual transition from Zeeman to Stark effect as the width of the $H\gamma$ line falls below about 4 A. Above this value the widths of the lines of the Balmer series are very well fitted throughout by parabolas through the origin. Below about 3 A. there is still evidence of the Zeeman increase of width with increase in wave-length beyond $H\gamma$; but for the lines of lower wave-length, the trend is reversed, and there is an increase in width with decrease in wave-length, presumably due to the Stark effect.

Furthermore, the contours of the bright lines in the spectra of these stars have frequently been found by Merrill to comprise maxima in the red and violet, as is to be expected from the Zeeman effect in a discharge channel.

It may also be noted that, on the aforementioned view[5], novæ are also the result of still greater electrical discharges, during which radial electric fields in stellar atmospheres of the dimensions of planetary systems are suddenly neutralized. It was found[3], as expected, that the broadening of the spectrum lines during the *initial stages* of a nova outburst is, in fact, proportional to the square of the wave-length, as required by the Zeeman effect, and not proportional to the first power of the wave-length, as it would be if, as is generally supposed, the broadening is the consequence of Doppler effect.

It has since been pointed out to me that Wright[7] had earlier come to the same conclusion as regards the existence of the quadratic law of line broadening, from his measurements on the spectrum of Nova Geminorum on March 16 and 18, 1912. Even on March 23, nine days after maximum, the quadratic term in the expression for the width of the lines in terms of their wave-lengths accounted for nearly 40 per cent of the total width of $H\alpha$.

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[1] Ellison, M. A., *Nature*, **163**, 749 (1949).
[2] Ellison, M. A., and Hoyle, F., *Observatory*, **67**, 181 (1947).
[3] Bruce, C. E. R., *Observatory* (in the press).
[4] Bruce, C. E. R., *Proc. Inst. Elect. Eng.*, **95**, Part III, 337 (1949).
[5] Bruce, C. E. R., "A New Approach in Astrophysics and Cosmogony" (London, 1944).
[6] Curtiss, R. H., *Pub. Ast. Observ. Univ. Michigan*, **3**, 1 (1923).
[7] Wright, W. H., *Lick Obs. Pub.*, **14**, 27 (1936).

Mr. Bruce believes that the short-lived broadening which we observe in the Balmer emission lines during the 'flash' phase of an intense flare arises from a temporary magnetic field of the order of 10^3 gauss. If this is so, some explanation is needed of the fact that no comparable Zeeman broadening has been recorded in the emission lines of iron, calcium and silicon as photographed by C. W. Allen[1] and myself[2]. Most of these lines show (in absorption) the normal Zeeman effect in sunspot spectra, where the fields are of the order of only 10^3 gauss.

Dr. H. von Klüber tells me that he has made a special search for Zeeman effects associated with flares, using for this purpose the Potsdam solar tower telescope and employing the Hale technique of quarter-wave plate plus polarizer in front of the primary slit of his spectrograph. These preliminary experiments, of which no account has yet been published, have failed to indicate any fields greater than 10^3 gauss in the flare regions. However, these tests were carried out mainly on the *absorption lines* λ 6173 and λ 6303, which have large and simple Zeeman patterns of the form (0)5/2. It might well be that if the magnetic fields were of very local occurrence in the chromosphere, confined perhaps to a narrow path as Mr. Bruce seems to suggest, they would produce no observable effects of broadening in absorption lines which are formed in the reversing layer, possibly at a different level. Thus, I think, it is very important that further tests of this kind should be carried out on the *emission lines* from the flare filaments.

Finally, arguments based upon the relative widths of $H\alpha$, $H\beta$, etc., in emission are at present inconclusive, since the range of the Balmer series in a flare has so far only been covered by a number of overlapping plates. Owing to the rapid variation of

flare intensity with time, it is essential to record on a *single* plate the whole spectral region under discussion.

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[1] Allen, C. W., *Mon. Not. Roy. Ast. Soc.*, **100**, 635 (1940).
[2] Ellison, M. A., *Mon. Not. Roy. Ast. Soc.*, **106**, 500 (1946).

Atmospheric Oscillations

Pekeris[1] showed that in a long-period oscillation of the earth's atmosphere the divergence of the velocity vector satisfied a second-order differential equation, and that at high level (where he assumed for simplicity that the air temperature was constant) the two solutions of this equation were proportional to exp $[ist + (\frac{1}{2} \pm i\mu)x]$; x is the height measured in terms of the scale height, and μ is a (real or imaginary) quantity depending on the temperature of the atmosphere. The velocity components are proportional to the same expression. The static air pressure, p_0, is proportional to exp $(-x)$.

Pekeris suggested that the appropriate solution to take at high level was the one in which the energy density (which is proportional to $p_0 u^2$, where u is the velocity vector) was finite. This criterion enabled a choice between the two solutions to be made if μ were imaginary, but failed if μ were real, since both solutions then gave a finite energy density. Pekeris pointed out that in this case a choice could be made by including in the analysis the effect of a damping agency, and chose for the purpose heat conduction. He found that the solution in which the energy density decreased exponentially with height was that with the upper sign if $\mu > \frac{1}{2}$, and that with the lower sign if $\mu < \frac{1}{2}$. This led to certain difficulties of physical interpretation associated with the discontinuous change from one solution to the other near $\mu = \frac{1}{2}$, and Weekes and Wilkes[2] suggested as an alternative criterion that the solution which corresponded to an upward flow of energy should be taken. They showed that this was always the one with the upper sign, whatever μ.

Both these arguments appear to be legitimate, and it is not immediately clear why they should give conflicting results when $\mu < \frac{1}{2}$. In order to resolve the contradiction it is necessary to examine the assumptions on which they are founded.

Two arguments are usually given to show that heat conductivity causes damping of sound waves. One is based on the fact that heat flow down a temperature gradient is an irreversible process, and causes part of the ordered energy of the wave to be degraded into heat. The second is based on a mathematical discussion by Kirchhoff[3] of the propagation of sound in a uniform conducting medium. This follows the ordinary treatment of the propagation of sound, except that the equation of conduction of heat is used instead of the adiabatic equation of state. Second-order terms are neglected, and a periodic solution is assumed. It is shown that the amplitude of the wave decreases exponentially in the direction of propagation.

Consideration will show that these two arguments do not both apply to the same physical system. One concerns the propagation of a wave packet in an insulated medium, the temperature of which is raised by the passage of the wave. The other concerns the propagation of a sustained wave in an atmosphere the mean temperature of which is artificially maintained constant. Since in the second case heat must be removed from the medium, or supplied to it, in order to keep the mean temperature constant, no argument based on conservation of energy is applicable. The fact that Kirchhoff's analysis leads to a wave attenuated in the direction of propagation must therefore be regarded as an independent fact, and not as a confirmation of what would be expected from considerations based on the conservation of energy.

The analysis given by Pekeris is an extension of Kirchhoff's analysis to the case of a rotating atmosphere under the influence of gravity. From what has been said, it will be realized that there are no general grounds for supposing that the wave will necessarily be attenuated in the direction of energy flow, and, in fact, the result shows that this is only the case if $\mu > \frac{1}{2}$. If $\mu < \frac{1}{2}$, the wave increases in amplitude, heat being drawn from an external reservoir the presence of which is implied by the assumption of periodic motion.

If radiation is taken as the damping agency in place of heat conductivity, no similar difficulty arises, since the heat given up by the wave is removed from the atmosphere and there is no inconsistency in assuming that motion is periodic. An analysis similar to that of Pekeris then gives a wave which is always attenuated in the direction of propagation.

Although the paradox here discussed first arose in connexion with long-period oscillations of the atmosphere, it has been found that a similar phenomenon occurs in the case of the vertical propagation of plane sound waves in an atmosphere in equilibrium under gravity, and it is hoped to discuss the matter from this point of view elsewhere.

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Feb. 22.

[1] Pekeris, *Proc. Roy. Soc.*, A, **158**, 650 (1937).
[2] Weekes and Wilkes, *Proc. Roy. Soc.*, A, **192**, 80 (1947).
[3] Kirchhoff, *Pogg. Ann.*, **134**, 177 (1868). See Lamb, "Hydrodynamics" (Cambridge University Press, 1932, 6th ed., p. 648).

Reciprocity Theory of Electrodynamics

In our previous communications in *Nature*[1], we have given an account of the bearing of the principle of reciprocity on the theory of elementary particles, with particular reference to the determination of the natural rest masses. Attention has now been given to the application of this general theory to electrons and electromagnetic field. The orthodox theory cannot be regarded as satisfactory, on account of the well-known divergence difficulties, recently re-examined by Schwinger, who had considerably developed the pioneer work of Weisskopf and Dirac[2] in a covariant way. These difficulties can be removed either by introducing non-linearity in the radiation field, in the way attempted by Born and Infeld[3], or by preserving the linearity but introducing high derivatives of the field variables, as has been done effectively by Podolsky[4] and Bopp[5].

The arbitrariness of these methods is removed by acceptance of the principle of reciprocity, which predicts for the radiation field a Lagrangian of the form:

$$L = \int F_{kl} A^k A^l dx^{(3)},$$

$$F^k{}_l = \tfrac{1}{2}\lambda^{-2}\, p^k p'_l e^{-(P+P')/2b^2}, \qquad (1)$$

where $P = p^k p_k$, and the auxiliary condition $\frac{\partial}{\partial x_\mu} = 0$ is imposed. It can be shown for the pure radiation field that the factor $e^{-(P+P')/2b^2}$ does not lead to any consequences different from those of the orthodox theory; but if the electron is considered in the usual way to be a point singularity in the radiation field, so that the equation of the field of a moving electron is

$$e^{-a^2\square}\,\square A_k = \frac{ev_k}{c}\,\delta\{x - x_e(t)\}\,,\ v_k = \left(\frac{dx_e}{dt}, c\right), \quad (2)$$

the solution is finite everywhere, reducing to the usual solution at large distance, and to the difference between the retarded and advanced potentials introduced by Dirac[6] in the first approximation at small distance from the singularity. The energy and momentum of the field are also finite, and are identified with the energy and momentum of the electron. In this way the idea of Abraham[7] has been realized without the relativistic difficulties associated with a rigid electronic structure.

Before quantization, a Hamiltonian formulation is required, for which, because of the appearance of high derivatives in the Lagrangian, either the well-known method of Lagrangian multipliers or a method of successive approximation may be used. The interaction energy then has the form:

$$H_i = e\alpha\,.\,\Sigma e^{-\{a^2-(k\,.\,p)^2/E^2\}/2b^2}\,B(k)e^{ik\,.\,x/\hbar} + B^*(k)e^{-ik\,.\,x/\hbar}\,e^{-(k^2-(k\,.\,p)^2/E^2)/2b^2}, \quad (3)$$

where $E = (p^2 + mc^2)^{1/2}c$ is the energy of the electron with momentum p. The order of the factors is essential to the convergence of the electromagnetic self-energy, and is decided by the usual requirement that the emission operator $B(k)$ is written last and the absorption operator $B^*(k)$ first in proceeding to the quantum theory. This ensures that the contribution of all roundabout transitions to the self-energies and cross-sections are small and finite, while leaving the real processes unaffected except to a small and rather interesting degree which, it may be hoped, improvement in experimental technique will confirm.

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Calculation of Factorial Moments of Certain Probability Distributions

I HAVE recently[1] been investigating certain probability distributions arising from points possessing one of k colours or characters arranged on a line or in the form of a rectangular lattice. In the course of these investigations it has been possible to establish the undermentioned theorem, which has proved to be very useful in evaluating the factorial moments of many probability distributions of a discrete nature.

Theorem. The rth factorial moment about zero for the probability distribution of some specified discrete character (or characters) is $r!$ multiplied by the expected number for r of the specified character (or characters).

The binomial and the hypergeometric distributions are the simplest cases where this theorem can be applied direct. For these distributions, the rth factorial moments, $\mu'_{[r]}$, are

$$r!\binom{n}{r}p^r = n^{(r)}\,p^r \text{ and}$$

$$\frac{r!\binom{n}{r}(Np)^{(r)}}{N^{(r)}} = \frac{n^{(r)}\,(Np)^{(r)}}{N^{(r)}},$$

respectively. They are evidently $r!$ times the expectation for r of the events.

Some of the other distributions which can be applied in this theorem are: (*a*) the theory of the distribution of black–black, black–white and other joins arising from points possessing any one of k colours arranged on a line or in the form of a rectangular lattice; (*b*) the distribution for the number of runs in ascending or descending order discussed by Kermack and McKendrick[2], which ultimately is the same thing as the distribution of peaks and troughs discussed by Kendall[3]; and (*c*) the distributions arising in the matching theory dealt with by Batin[4], Anderson[5] and Wilks[6]. It is also felt that the theorem will be useful in evaluating the factorial moments of many other distributions. The application and the proof of this theorem will be discussed in detail elsewhere shortly.

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The Word 'International'

IT has unfortunately become a too common habit to prefix the word 'international' to the title of institutions which have no claim to be so described. A recent instance is the announcement of an 'International' Congress of Mediterranean Prehistory and Protohistory, to be held in Florence in the spring of 1950. Its title is evidently modelled on that of the International Congress of Prehistoric and Protohistoric Sciences, a fully organised international society which met in London in 1934, and at Oslo in 1938, and is now arranging its third meeting, also for 1950. But the Italian 'Promoting Committee' consists only of seven Italian professors, and though it is patronized by the Italian Ministry of Education and the Foreign Office, it is 'sponsored' only by Italian institutes – at Rome, Florence and Bordighera. The circular announces that other Italian and foreign institutions will be named later on. But this is not good enough. It is time that some protest was made against the misuse of so significant a word as 'international' by bodies which have no claim to it.

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A NEW ION SOURCE FOR MASS SPECTROMETRY

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THERE have been only two types of ion source which have been successfully applied in mass spectroscopy to isotopic abundance measurement and to quantitative chemical analysis. One is the hot-anode source, the other the source obtained by using an electron gun to bombard the entering gas stream. Only this second type is considered here; it gives stable conditions of ionization and flexibility in control. The purpose of this communication is to describe a new model of this type of source; but it will be well first to summarize briefly the aims in source design and to refer to the prevalent design.

In a stable ion source of this type, the entering gas is introduced as a well-defined molecular beam which is intersected in its passage through the source by an electron beam directed at right angles to it. The ions created by impact are usually withdrawn in the direction of the molecular beam and focused by means of an ion gun into a beam of minimum divergence. In the design, the first aim is high sensitivity. This means a high efficiency for the peak intensity of the ion beam at any mass number M within the mass-range of the instrument relative to both the electron beam intensity used and to the particle density in the gas stream of atoms or molecules of mass M. The second aim is freedom from source aberrations involving loss of resolution. A major aberration arises from a large velocity spread of the ions. With a large velocity interval, velocity focusing or velocity selection devices really become necessary to obtain adequate mass-resolution; the apparatus becomes quite complicated with inevitable loss of sensitivity. The electron gun is therefore designed to limit the spread of ion energy to a maximum of 10 volts, so that refocusing of the ion beam in respect of direction only is all that is necessary, and this is done by the main analysing magnetic field. Thirdly, the ion source must not discriminate between the different molecular species in the entering gas. In most sources there is great danger of this discrimination of mass, with the consequence that the results obtained are not truly proportional to the abundances of the entering species. The cause of mass-discriminations in the source may be space-charge effects, differences in the initial kinetic energies, variations in the efficiency of the ionization process from one mass to another, or selective ion deflexions due to the presence of strong magnetic fields in the source region. Finally, the peak intensity obtained in the analysis should not depend on the accelerating voltage applied to the ion gun, though this is an effect observed in many instruments.

Three main arrangements have been described for electron bombardment of a molecular beam: (1) by Coggeshall and Jordan[1]; (2) by Heil[2]; (3) by Dempster[3], Smythe[4], Bleakney[5], Tate and Smith[6], and by Nier[7]: the prevalent one, largely due to Nier, is sketched in Figs. 1*a* and *b*. It has small energy-spread and fairly high sensitivity; but is open to the following criticisms:

(*a*) The electron beam in a central section of the source is directed parallel to the long axis of the first ion slit, that is, parallel to the direction of the main analysing magnetic field. To hold the electron beam to its course against the potential required to draw out the ions created, magnetic focusing is employed. A substantial magnetic field must be used to align the electron beam. Thus in the sector-field type instrument, an auxiliary magnetic field is provided in the source region and its adjustment is somewhat critical. The auxiliary fields used vary in different instruments using this source from 200 to 1,000 gauss[8]. In the 180°-type spectrometer, the field required is supplied by the main analysing magnetic field, since with this type the source region is almost completely immersed in that field. Ions are thus drawn from crossed electric and magnetic fields, and mass-discriminations due to magnetic effects on the ions become more likely. Trochoidal motion of the ions ensues upon drawing out the ions created, so that pre-focusing half-plates flanking the beam as shown become necessary to align the ion beam for maximum intensity.

(*b*) With this design, no 'grid' control of the electron emission from the filament is used, the electron gun consisting simply of filament and anode. Entry of the electron beam to the ionization chamber is controlled by a single defining slit at one end of the chamber. Consequently, the electron current to the trap is at most only about 10 per cent of the total emission.

(*c*) The sensitivity of this source depends on the accelerating voltage applied to the ion gun and falls off rapidly for accelerating voltages less than 500 volts. The laws of this voltage-dependence have never been explained in detail, and the true absolute abundances thus remain in doubt.

From July 1947, work has been in progress at the National Physical Laboratory on an examination of the factors determining resolution, sensitivity and accuracy in mass-spectrometry. Part of this work has been a study of ion-source design. A considerable number of workable ion-source arrangements has been examined in an effort to evolve a design for a source in which, first, a much-reduced magnetic field intensity is required, so minimizing the danger of mass-discrimination, and secondly, more efficient use is made of the avail-

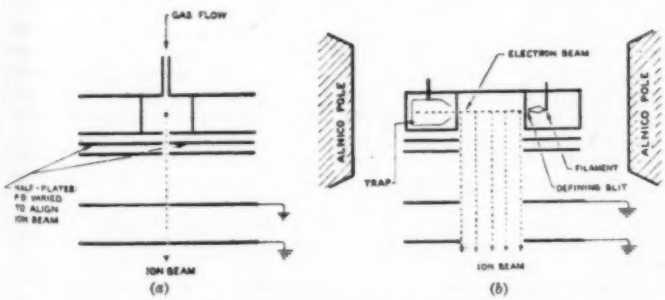

Fig. 1. Electron bombardment source (Nier type) for mass spectrometry. Main sector field (*a*) perpendicular, (*b*) parallel to plane of paper

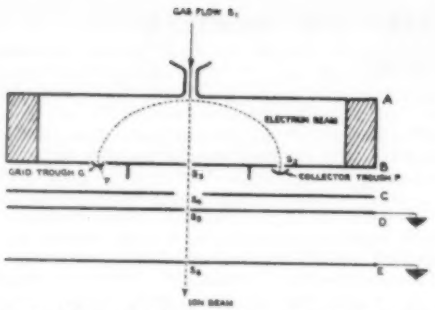

Fig. 2(a). Schematic diagram of ion source (central section)

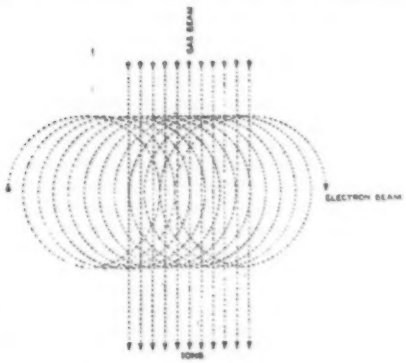

Fig. 2(b)

able electron emission to give improved sensitivity. The mass-spectrometer itself, constructed during 1946 and the early part of 1947, is an all-metal instrument, designed as a precision engineering job with every facility for easy dismantling and re-assembly. It uses a magnetic angle of 60° and ion beam of 4 in. (10·16 cm.) radius, direction focusing only being employed.

Throughout the work on ion sources, 'grid' control of the filament emission has been used, in the first instance by the use of a two-slit system (first—slit, grid; second—slit, anode) for the production of a quasi-parallel beam according to the simple field geometry of Davisson and Calbicks[9] for line sources. However, in much of this work trochoidal motion of the electron beam has been used, and in these cases a slit system to focus the beam has been found to be unnecessary, so long as some form of 'grid' control is retained. Perfect focusing of the electron beam throughout its entire path in crossed electric and magnetic fields can be achieved in the following simple manner.

In Fig. 2*a* a homogeneous magnetic field of about 25–30 gauss is to be taken as perpendicular to the plane of the paper and parallel to the long axes of the ion slits. A filament consisting of a tungsten wire (0·004 in. (0·01 cm.) in diameter) spot-welded to a non-magnetic alloy of nickel and copper is mounted under tension at F parallel to the magnetic field. The filament lies symmetrically as shown in an open semi-circular trough G, the potential of which is adjusted, for perfect focusing of the beam, to be between 10 and 50 volts negative with respect to the filament. The potential of plate A, which forms the anode of the electron gun, is adjusted so that the beam passes immediately below the gas entrance slot S_1, and then through the wide slit at S_2 to be collected by trough P. The potential of plate A depends, of course, on the selected geometry and may be up to 150–200 volts, positive with respect to the filament. The potential of plate B is negative with respect to A by up to 50 volts; the potential of collector trough P is maintained positive with respect to B to avoid secondary emission. The thickness of the electron ribbon barely exceeds, on proper focusing, the filament diameter throughout its entire path.

It should be noted that (1) a much reduced magnetic field is required, and the possibility of magnetic effects on the ions is practically eliminated; (2) the ions are drawn perpendicular to the parallel plates A and B straight through slit S_2, so that pre-focusing half-plates are not required (the ion beam should not 'see' the filament and collector assemblies; details of the various screening arrangements are omitted for the sake of clarity); (3) practically the whole emission (more than 99 per cent) from the filament is effective for ionization and is received by collector trough P; this means an important gain in sensitivity; (4) the spread of ion-energy does not exceed one to two volts.

For the ion gun, a slight retarding field is held between plates B and C, the purpose here being to bunch the ion beam, and limit the divergence arising from space-charge effects. The main acceleration, approximately 2,000 volts, occurs between plates C and D. Plates D and E are grounded. The width of slit S_4 together with the separation of plates C and D determine collimation of the ion beam. In any design, careful attention should be given to radii, properly blended, on all edges to reduce field distortion and cold field emission. Slit S_4 defines entry of the ion beam to the magnetic analyser, and its width is determined by the design geometry in respect of resolution.

This source is intended for use with the sector-field type instrument. If the magnetic field required in the source region (about 25 gauss) is supplied by the stray field from the main magnet, magnetic scanning cannot be employed. In the N.P.L. mass-spectrometer, the stray field in the source region is normally in excess of that required for proper functioning of the source described. Consequently, an opposing field is supplied by Helmholtz coils fed from and controlled by the main magnet supply. By suitable design, the desired field in the source region obtained as a difference between two fields (stray field and Helmholtz coils) is automatically held constant over a wide range of adjustment of magnet current. In other instruments, an alternative method may be to shield out adequately the stray field and to supply the desired fixed field by Helmholtz coils.

In the source described above, one loop of a prolate trochoid (in fact, almost a cycloid) is employed for the electron path. In recent experimental work, curtate trochoidal paths have been used (see Fig. 2*b*), so that with the electron ribbon returning almost to the point of issue, many revolutions of the electron ribbon can occur in the molecular beam. In consequence of the increased path-length of the electrons in the gas beam, much more intense ionization ensues, with a further gain in sensitivity. With the geometry used, however, it has been found so far that the price to be paid for this extra gain in sensitivity involves increase of the energy-spread of the ions and increase of the magnetic field (up to 150 gauss) in the source region. Further work is

necessary on a more complicated source of this type to overcome these defects. It is not proposed at present to proceed with this work, for the simple source described satisfies the initial demands in respect of reduced intensity of magnetic field in the source region, and of improved sensitivity, for which the work was undertaken as part of the main programme of work on mass-spectrometry. On the final analysis, this gain in sensitivity may well prove to be ten times or more.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory. Detailed publication will follow in due course elsewhere.

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PRODUCTION OF HEAVY MESONS IN COSMIC RAY STARS

By J. B. HARDING and Dr. D. H. PERKINS
Imperial College of Science and Technology, London

COUNTER and cloud chamber[1] evidence indicates that mesons originate in collisions of fast nucleons with nuclei, the recoiling nucleons giving rise to stars of heavy charged particles. As yet it is not quite certain whether only π-mesons (mass 286 m_e), which are known to have strong coupling with nucleons and decay into light μ-mesons (mass 215 m_e), are generated, or if light mesons can also be directly produced. Observations by Occhialini and Powell[2] on very slow mesons generated in stars in nuclear emulsions, and the artificial production of π-mesons at Berkeley[3], are in favour of the former hypothesis. In this note we describe measurements of the absorption of π-mesons in dense matter, from which we can determine approximately their rate of production and energy spectrum.

The experiment consisted of exposing boxes of Ilford *C*2 plates, 100 μ thick, horizontally in a narrow crevasse, $\sim$ 10 cm. wide, in a glacier at Jungfraujoch (3,650 m.) (for details see *Nature*, **163**, 319; 1949). The numbers of heavy mesons coming to rest in the plates, both π^+ and π^- at different depths, are given in the accompanying table.

If π-mesons are generated only in star processes, we would expect that, at sufficiently great depths in the ice, the stars and mesons would be in equilibrium, and, indeed, at depths greater than 200 gm./cm.^{2}, the observed ratio of mesons stopping to stars appears to be constant to within the statistical error (see Fig. 2). It is to be noted that the star intensity itself varies by a factor of ten between top and bottom points. Further, the intensity of the mesons which have been generated in an upward direction, whatever their angular and range distributions, will vary exponentially with depth, in the same way as the stars. Since, as will be shown below, the number of downward-generated mesons coming to rest in plates at the surface of the ice is negligible, the upward meson flux is represented by the shaded area of Fig. 2. We see, first, that the upward-generated mesons form only a small fraction of the total; secondly, that they have no influence on the transition effect, that is, the shape of the curve in Fig. 2, or the position of the maximum in Fig. 1 (*b*).

For a mathematical analysis of our results we have made the following simplifying assumptions: (1) The rate of production of mesons at a given depth is proportional to the star intensity at that depth. (2) The meson-producing radiation and the mesons so produced travel vertically downwards, that is, the range of the mesons is equal to the vertical distance traversed. The effect of Coulomb scattering will only be important at the very end of the range. (3) Loss of energy of the mesons by ionization processes only need be taken into account.

Let S_x be the star intensity in the ice per c.c. per day at a depth x in the ice, S_0 be that at the surface. Then $S_x = S_0 \exp(-x/\lambda)$, where $\lambda = 200$ gm./cm.^{2}. Let α be the average number of mesons produced per star, $q(R)dR$ the probability that a meson is produced with a range between R and $R + dR$. Both R and x are measured in gm./cm.^{2}. Then, if $P(x)$ is the ratio (number of mesons coming to rest)/(stars at depth x), the range spectrum is given by

$$q(x)dx = \frac{1}{\alpha}\frac{dP}{dx}\exp(-x/\lambda)\, g(x)\, dx, \qquad (1)$$

where the decay factor

$$g(x) = \exp\left[\int_x^{\infty} \frac{E_0\, dx'}{c\beta\tau_0\,(E + E_0)}\right] \qquad (2)$$

E_0 being the rest energy (140 MeV.) of the meson, E and $c\beta$ being the kinetic energy and velocity corresponding to a range x'; τ_0 is the life-time $\sim 6 \times 10^{-9}$ sec.[4]. The decay term is of the order of unity.

In the above we have only considered those mesons originating in the ice. A similar treatment applies for those formed in the air above the ice; however, the decay term in this case makes the contribution from π-mesons originating in the atmosphere and coming to rest in the plates quite negligible.

Depth in gm./cm.^{2} ice	5	95	185	320	500
$\pi+ + \pi-$/c.c./day	0·37 ± 0·09	0·50 ± 0·12	0·64 ± 0·11	0·19 ± 0·05	0·10 ± 0·04
ρ/c.c./day (uncorrected for loss)	1·15 ± 0·16	0·97 ± 0·14	1·18 ± 0·15	0·97 ± 0·12	0·91 ± 0·11
$\left(\frac{\pi+ + \pi-}{\text{stars}}\right) \times 10^3$	2·6 ± 0·7	5·5 ± 1·4	10·1 ± 2·0	7·3 ± 2·1	7·5 ± 2·8

± indicates standard deviation

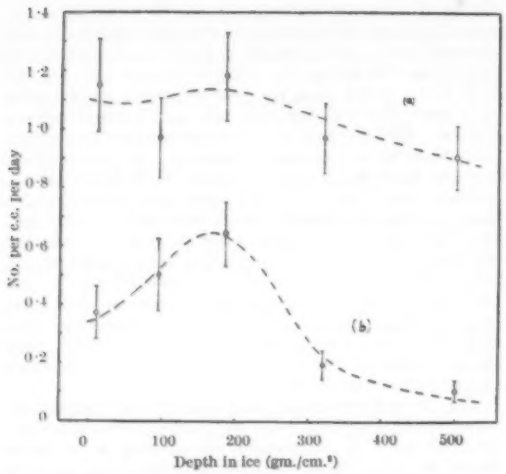

Fig. 1. Intensities of (*a*) ρ-mesons, (*b*) π-mesons at various depths in ice. Horizontal Ilford C2 plates. The values have not been corrected for 'loss'. The loss factors are ~ 1·5 for π-mesons and ~ 3·5 for ρ-mesons, computed from the observed range-distributions of the mesons in the plates, and observations on 200-μ electron-sensitive plates placed vertically. The hump in the dotted curve (*a*) represents the expected increase in number of μ-mesons from decay of locally produced π-mesons

From Fig. 2 we see that $P(x)$ reaches a saturation value, that is, $q(x)$ becomes very small, for $x >$ 300 gm./cm.². This range corresponds to an energy of 600 MeV. The actual spectrum, obtained by differentiating the $P(x)$ curve and inserting the values in equation (1), gives a mean range $\overline{R}$ of approximately 100 gm./cm.² (energy 250 MeV.).

We determine the rate of production of mesons by integration of equation (1). But we have first to calculate the rate of star production S_0 in the ice itself, from the experimentally determined rate of production in photographic emulsion on the ice surface. This is 15 stars/c.c./day[5], of which 5 c.c./day are produced in light elements[6] (carbon, oxygen and nitrogen). From the constitution of gelatine and ice, S_0 will also be 5/c.c./day, that is, one third of the rate in an equal volume of photographic emulsion. On the other hand, the stopping power of the ice for slow mesons, relative to that of the emulsion, is about one third, so that the ratio (mesons stopping/stars) is the same for equal volumes of ice and emulsion. Measurement of the track-length distribution of the π-mesons in our plates indicates that we must multiply the observed number of mesons by a factor of 3/2 to account for those with very short tracks which escape detection. Taking account of these corrections, integration of equation (1) gives $\alpha = 0{\cdot}1$.

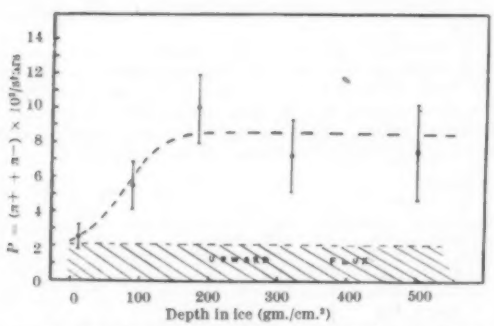

Fig. 2. Ratio of π-mesons stopping per c.c. to stars per c.c. in plates at various depths in ice

This result can be checked in order of magnitude by considering the equilibrium ratio of mesons to stars under great depths of ice. Taking the mean range of 100 gm./cm.², the number of mesons stopping per c.c. at equilibrium should equal the number starting 100 gm./cm.² farther up, divided by the decay factor. This gives $\alpha \sim 0{\cdot}09$, in reasonable agreement with the previous estimate.

The value of the mean range deduced above was obtained assuming the mesons to be generated vertically downwards. As stated previously, Fig. 2 indicates that possibly 25 per cent are generated upwards (35 per cent of the mesons coming to rest in the plates enter the emulsions from below, but any collimation effects will here tend to be obscured owing to the considerable Coulomb scattering of the mesons at low velocities). We believe that the value of $\overline{R}$ is unlikely to be low by more than a factor of two, because of the angular distribution of the mesons at the point of propagation. It also seems improbable that the value of $\overline{R}$ could be falsified by a change of the range spectrum $q(R)$ with the depth at which the mesons are produced; such a change would almost certainly be accompanied by one in the size distribution of stars with depth, contrary to what is observed.

In converting the mean range $\overline{R}$ to mean energy, we have assumed that only ionization losses are important. It is quite conceivable, however, that fast mesons lose additional energy by themselves producing further stars. Assuming a geometrical cross-section for such processes, which corresponds to a mean free path of 60 gm./cm.², the additional energy of the meson will be approximately $\overline{R}/60 \times$ mean star energy. Taking the latter as ~ 200 MeV., the average meson energy might be increased to about 500 or 600 MeV. These additional stars would produce a change in the observed absorption, that is, the star intensity for depths beyond one metre of ice would be increased relative to that at the surface by about 20 per cent. However, any deviation from the exponential absorption is certainly less than 10 per cent[5], corresponding to a mean free path for fast meson interaction of greater than 120 gm./cm.² and an additional energy loss of less than 200 MeV. Thus taking into account our poor statistics, the unknown angular distribution of the generated mesons and possible energy loss by star production, we obtain lower and upper limits of 250 MeV. and 700 MeV. for $\overline{E}$. We can certainly say, however, that the mean range $\overline{R}$ is between 100 and 200 gm./cm.² of ice.

The absorption observed for the 'single' (ρ) mesons (known to be predominantly μ-mesons) is characteristic of that of the hard component (see table and Fig. 1). There should be a small increase in number in the vicinity of the maximum of the absorption curve for π-mesons, owing to decay of the latter. The observed magnitude of any possible increase is consistent with the assumption that the direct production of μ-mesons from stars formed in the ice is small compared with the rate of production of the π-mesons, and allows us to put a lower limit to the life-time of the heavy mesons. We obtain

$\tau_0 > 2 \cdot 10^{-6}$ sec., in agreement with the results of other observers[4]. The high value of the mean energy ($\sim 10^{10}$ eV.) of μ-mesons at this altitude indicates that the average energy of production of the μ-mesons, or of the π-mesons of which they are the decay products, is large compared with the value $\overline{E}$ given above. This is consistent with the assumption that the μ-mesons result from the much more energetic disintegration stars produced in the high atmosphere.

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ANNUAL REPORT OF THE FORESTRY COMMISSIONERS

THE report of the Forestry Commissioners for the year ending September 30, 1947 (London: H.M. Stationery Office; 1948), covers the first complete year of the post-war forestry programme. Forest policy came under review in the House of Commons in November 1945 and again in October 1946. On this latter occasion the Minister of Agriculture and Fisheries made an important announcement which was, in fact, a full statement on forestry.

The opening portion of this statement merits careful study, and runs as follows: "On 30th November last year I made a statement in this House on Government Forest Policy. After careful and detailed study, the Government were impressed with the necessity, as a safety measure, apart from all other considerations, to rebuild our reserves of standing timber as quickly as possible. The Government were also impressed with the possibilities that systematic forestry and afforestation held out for the better utilisation of large areas of poor land, and increased employment in healthy rural surroundings for quite a considerable body of people. We proposed, therefore, at that time to ask the Forestry Commission to prepare for what we regarded as large-scale action. My right hon. Friend the Chancellor of the Exchequer readily agreed to replenish the Forestry Fund by some £20 million during the five years 1946–50. The first instalment of that figure appears in the Estimates for the current financial year. This sum of £20 million is expected to provide for the afforestation and replanting of something like 365,000 acres by State action and by assistance to owners of private woodlands, for the acquisition of land, for increased facilities for education, training and research into all branches of forestry, for up-to-date houses for forestry workers, and for national forest parks; and in addition, of course, the maintenance and development of the large areas of young plantations already established by the Forestry Commission."

It is common knowledge that the First World War considerably depleted the woodlands of Britain —practically all privately owned and grown woodlands. The Second World War has nearly cleared all the conifer areas, and the hardwood areas since the close of the War are now bearing the brunt of home fellings to a dangerous extent. It was the tardy recognition by the Government in 1919 of our almost total dependence on imports of the soft-wood timbers which caused the Forestry Bill to be passed in the House of Commons.

We are in whole agreement with the Minister in his belief that timber will remain an essential raw material for industry for a long time. But his reason for speeding up planting operations in Great Britain —because in the great forests from which the overseas supplies had come the growth was not keeping pace with the depletion—is a sorry statement for a Minister of State to make on the forest administration of the Colonial Empire (it would not be true of India, but she is no longer in question). It is true the forests have been regarded mainly from the point of view of luxury timber producers, worked to this end by timber merchants, the Government taking absurdly small royalties for a produce which belonged to the people of the country it was ruling.

The report also deals with the dedication scheme for the owner of private woodlands. But since the report was written it would appear that some modifications will be necessary in the Commission's original ideas on this subject.

The following programmes are of interest for the five-year period 1946/47–1950/51. The planting programme is: England, 118,400 acres; Scotland, 123,400; Wales, 48,200; private forestry, 75,000. Total, 365,000 acres. The land acquisition programme is: England, 420,000 acres; Scotland, 330,000; Wales, 176,000. Total, 926,000 acres—or nearly a million acres in the five years.

The Commission may be congratulated on having produced a concrete plan which can be worked to without the ambiguities which are overshadowing so much of the piecemeal, so-called town-planning and other operations throughout Great Britain. Some of these latter are in the hands of more than one controlling or advisory authority; and the conflicting interests thus engendered appear, in some cases, to be dangerously imperilling the future food-raising possibilities by taking fertile agricultural land for building or new road work and so forth.

NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

NEW APPOINTMENTS

IN connexion with the founding of the New South Wales University of Technology (see *Nature*, July 30, p. 195) appointments in the University have been made as follows.

Chair of Electrical Engineering: Mr. H. J. Brown. For the past two years Mr. Brown has been acting assistant director of the University of Technology and co-ordinator of research in the Technical Education Department. He will be responsible for the co-ordination of research in the new University. He graduated at Sydney, and has worked in the research laboratories of Amalgamated Wireless and as an electrical engineer in the Tasmanian Hydro-Electric Commission. During the War he became principal research officer in the Council for Scientific and Industrial Research and was one of the leaders in radar research and development.

Chair of Architecture: Mr. F. E. Towndrow. Mr. Towndrow is at present head of the Department of

Architecture in Sydney Technical College and Vernon Memorial lecturer on civic architecture in the University of Sydney. Before taking this he was senior architect to the Ministry of Works in London, and controller of experimental building development (Great Britain). He has made extensive studies in Europe, has exhibited in the Royal Academy and is the author of a number of books on architecture and planning. He is a member of the Council of the Town and Country Planning Association, London, and was for several years hon. secretary of the Arts Committee of the Royal Institute of British Architects.

Registrar : Mr. J. C. Webb. A graduate of the University of Wales, Mr. Webb was engaged there in lecturing and in research on mining problems prior to going to Australia. Since 1946 he has held the position of head of the Mining Engineering Department of the Technical Education Department and has organised courses of mining instruction throughout New South Wales. In this capacity he was responsible for the establishment of the first coal-mining engineering degree course in Australia, together with a valuable scholarship scheme to provide financial assistance to students in the course. Mr. Webb is keenly interested in students' welfare and has taken an active part in the organisation of the social and sporting activities of students in the new University.

Chair of Chemical Engineering : Dr. J. P. Baxter, O.B.E. After graduating at Birmingham, Dr. Baxter won a Priestley research scholarship (1925–27) and later a James Watt research fellowship (1927–28) of that University during investigations in mechanical engineering and chemistry for which he was awarded the Frankland Medal. In 1928 he was appointed to the research staff of the General Chemicals Division of Imperial Chemical Industries, Ltd., becoming research manager in 1936 and director of the Division, in charge of their research laboratories, in 1945. Dr. Baxter has been connected with the development of many new chemical products such as polyvinyl-chloride, 'Gammexane' and organic fluorine compounds, together with a comprehensive programme of research into chemical engineering problems. During the War he was responsible for intensive researches on chemical warfare problems and collaborated on the chemical side of the atomic energy programme. In this connexion Dr. Baxter, at the request of the British Government, went to the United States in 1944 to join the American team working on atomic energy at Oak Ridge, and remained on this work until after the War. For his work on atomic energy development he was awarded the O.B.E. in 1945.

Chair of Mining Engineering : Dr. D. W. Phillips. Dr. Phillips is a certificated colliery manager, and has served as an officer of the Safety in Mines Research Board, first as a mining engineer and geologist and later as chief mining engineer. In this capacity he was responsible for the direction of research on problems of haulage, subsidence and roof control in mines, and of shotfiring in coal mines. In 1943, he was appointed principal scientific officer to the Safety in Mines Research Board and, following the nationalization of the British coal industry, was appointed chief safety engineer to the National Coal Board. A graduate of the University of Wales and a Ph.D. of Cambridge, Dr. Phillips has established a high reputation as an authority on roof control in mines, and has published a large number of papers on the subject in British and European journals.

Chair of Applied Chemistry : Dr. A. E. Alexander. A fellow of King's College, Cambridge, Dr. Alexander is at present assistant director of research in the Department of Colloid Science, Cambridge. He was awarded the Ramsay Memorial fellowship in 1937 and the Rockefeller travelling scholarship in 1939, the latter enabling him to work in the Department of Medical Chemistry in the University of Uppsala with Prof. T. Teorell. He was the Tilden lecturer of the Chemical Society in 1947. He has been engaged in research and teaching at Cambridge since 1935, chiefly in the field of surface chemistry, polymers and colloid chemistry. During the War he did research for the British Ministry of Aircraft Production and the Petroleum Warfare Department, working on polymers, aluminium soaps, camouflage, and rubber substitutes. In the industrial field Dr. Alexander has been adviser to industrial undertakings, particularly in connexion with paints, emulsions, soaps and detergents. He is the author of a large number of publications on colloids, surface chemistry and polymers and has recently particularly concerned himself with the effect of the surface activity of substances on their microbiological and drug action.

NEW SEISMIC STATION AT GALERAZAMBA, COLOMBIA

By The Rev. J. E. RAMIREZ, *S.J.*
Director

TOWARDS the second half of January 1949, the new seismic station at Galerazamba was completed with newly installed Sprengnether seismographs. It is located in the northern part of Colombia between the cities of Cartagena and Barranquilla, 550 m. from the sea coast and 21 m. above sea-level, its geographical co-ordinates being 10° 47′ 08″ N. and 75° 15′ 44″ W. This modern station, together with the existing seismic centre at Bogotá and the one about to be inaugurated at Chinchiná, Caldas, will constitute a triangle of first-class seismic stations in Colombia.

The idea of establishing such a station developed during a conversation between Dr. Carlos Gómez Martínez, director of Sección Salinas del Banco de la Republica, and myself in the spring of 1945. The project, purposes and advantages of a seismic station at Galerazamba were later outlined and explained in detail by Dr. Martínez to the board of trustees of the Banco de la República, which gladly gave full approval to the project. The United States representatives of the seismic programme in the Central and South American Republics, Mr. Franklin P. Ulrich and Mr. Edward P. Hollis, added a new impetus to the project during their visits to Bogotá in 1946 and 1947, respectively. The up-to-date seismic equipment was ordered in 1947.

The plans and specifications employed in the construction of the seismic station were prepared by F. A. and Arthur Stauder of Saint Louis, Mo. The seismic station is a one-story concrete block building, without basement, the dimensions of the exterior walls being 9·60 m. for the length of the façade, 10·20 m. the sides and 3·60 m. in height. Besides the recording, seismometer and dark rooms, the building is provided with an observation room, a battery room and an office. Fibreglass insulation

was used for all exterior walls and ceiling, and also between double partitions around the recording and seismometer rooms. As a protection against humidity, a four-ply waterproofing membrane was applied over the entire floor surface after the pouring of the concrete base slab. The windows between the recording room and the observation room and those between the seismometer room and the office are composed of two panes of plate glass ¼-in. thick, hermetically sealed with metal to glass bond and separated by a dehydrated air space ¼-in. thick.

The seismic equipment consists of two Sprengnether horizontal-component long-period seismometers, a Sprengnether vertical-component short-period seismometer, and a triple drum. The station is further equipped with an air-conditioning apparatus, an electrically driven pendulum clock manufactured by the Standard Time Clock Co. and a Hallicrafter *SX*-42 radio receiver for the reception of time signals.

The station is built on the left bank of an old river-bed formerly used by the Magdalena River, and the seismic piers rest on hard reddish clay of probable Oligocene Age. Numerous mud volcanoes varying in size from several cm. to fifteen m. in height abound to the south-east of the station. Many of them are still active, especially Totumo Volcano, which is the largest and erupts twice daily. Off the shore and west of the seismic station there is a 'sunken peninsula' four or five km. in length, and according to many reliable authors this peninsula disappeared in October 1848. It was formed by sands and errant debris carried down by the Magdalena River into the ocean; in turn these objects drifted along the shore and clustered around several mud volcanoes scattered about in the sea not far off the coast of Galerazamba.

It is hoped that this new station at Galerazamba, working in conjunction with those at Bogotá and Chinchiná, will aid in localizing more accurately epicentres of Colombian earthquakes. Furthermore, this station will contribute valuable data to the solution of many international earth problems and give added incentive to the study of the eruptions of the nearby mud volcanoes and of the highly folded and faulted territory of Galerazamba. Finally, because of its strategic position, the Galerazamba station will also be utilized as a corner of a possible tripartite station for the purpose of recording microseisms caused by Caribbean hurricanes.

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In recent years, libraries and information organisations have tried to help men of science by supplying photocopies of papers reporting original work. However, except in special circumstances, permission to copy must be obtained from the copyright owner in every case, and this causes much tedious correspondence and delays.

Following a recommendation from its Scientific Information Conference, the Royal Society has considered, therefore, what action is needed to make it easier for men of science to obtain for the purpose of private study copies of papers in journals when these are not readily available by purchase or loan. As a result, the Council has made a Declaration stating that it will regard certain copying from its own publications as "Fair Dealing", and it invited other societies and publishers in Great Britain to subscribe to the Declaration. More than seventy have already done so. The full list can be obtained from the Royal Society.

The Declaration does not give permission to use published material in any way desired, and, in particular, it does not in any way apply to books and other non-periodic publications. It applies only to making, without profit and within stated conditions, a *single copy*; it does not give permission to use such a copy for any subsequent reproduction by any means; and it does not include permission to quote or reprint a whole or part of the work either in the original form, or as a digest.

It is not the intention of the Declaration to foster the substitution of copying for the purchase of journals. It is recognized that publishers of journals make a valuable contribution to the advancement of science by the dissemination of new knowledge, and that their interests must be safeguarded. The Declaration has been made for an experimental period of two years, and if a disproportionate volume of copying results, societies and publishers, in the interests of science generally, may be compelled to withdraw it.

Men of science and librarians are specially reminded that many publishers have available back numbers of journals and separates of papers, and publishers have made the Declaration on the assumption that all reasonable attempts to obtain an original will be made before making a copy.

The Declaration is as follows:

"For some time scientists have discussed the problems, created by the Copyright Act, which arise when they wish to obtain reproductions of excerpts from scientific and technical periodical publications. In the normal course of their work, scientists occasionally require for frequent reference, copies of particular papers appearing in scientific periodicals which are not readily available to them. It is assumed that they take all reasonable steps to secure the original journals or separates of papers they require, either from the author or the publisher, but it is recognised that many requirements cannot be met from these sources. We have, therefore, agreed to make the following declaration to ensure that scientists have no undue difficulties in obtaining copies from libraries and other organisations supplying information. This declaration does not apply to books and other non-periodic or non-serial publications.

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"We reserve the right to withdraw this declaration."

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT ANALYSTS (2) in the County Analyst's Laboratory—The County Medical Officer of Health, County Offices, Preston, endorsed 'Assistant Analyst' (August 20).

LECTURER IN THE DEPARTMENT OF METALLURGY of the County Technical College, Wednesbury—The Director of Education (Dept. F.E.), County Education Offices, Stafford (August 20).

TECHNICIAN IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Professor of Chemical Pathology, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (August 20).

EXPERIMENTAL OFFICERS as (*a*) Organic Chemists (Ref. F.497/49A), (*b*) Chemical Engineers (Ref. F.496/49A), and (*c*) Instrument Engineer (Ref. D.258/49A), at Ministry of Supply Research and Development Establishment in Lancashire—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 22).

FORESTRY INSPECTOR in the Ministry of Agriculture for Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (August 23).

LECTURER IN CHEMICAL ENGINEERING—The Registrar, The University, Leeds, 2 (August 27).

SENIOR SCIENTIFIC OFFICER (Ref. C.473/49A), for work including design of tunnel air circuits, particularly assessment of characteristics of fans and compressors, and SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS (Ref. C.474/49A), for work including design of supersonic nozzles and other parts of tunnel air circuits, at the Royal Aircraft Establishment, Farnborough—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting appropriate Ref. No. (August 27).

BACTERIOLOGIST IN THE DEPARTMENT OF MEDICINE—The Registrar, The University, Sheffield (August 27).

LECTURER IN ELECTRICAL ENGINEERING—The Registrar, The University, Leeds, 2 (August 29).

PRINCIPAL of the Farm Institute to be established on an estate near Norwich—The Chief Education Officer, County Education Offices, Stracey Road, Norwich (August 29).

HYDRO POWER STATION DESIGN ENGINEER to the State Electricity Commission of Victoria—The Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2 (August 30).

EDITOR or ASSISTANT EDITOR for the *Journal* of the Society—The General Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1 (August 31).

ORGANIC CHEMIST for Fruit Products Investigations at Long Ashton Research Station—The Secretary and Registrar, The University, Bristol (August 31).

SCIENTISTS (Grade III), at the London headquarters (one with a university honours degree in physics or mathematics, and the other with a university honours degree in chemistry or the equivalent)—The National Coal Board, Establishments (General) Branch, Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/155 (August 31).

SCIENTIST (Grade II) (Ref. TT/156), and a SCIENTIST (Grade III) (Ref. TT/157), on the headquarters staff of the Coal Survey organisation—The National Coal Board, Establishments (General) Branch, Hobart House, Grosvenor Place, London, S.W.1, quoting the appropriate Ref. No. (August 31).

RESEARCH ASSISTANT (BIOCHEMIST) IN THE DEPARTMENT OF ANÆSTHETICS—The Registrar, The University, Leeds, 2 (August 31).

ASSISTANT CURATOR (male) for the Geology Department, and an ASSISTANT CURATOR (male) for the Botany Department of the Natural History Museum—The Town Clerk, The Guildhall, Nottingham (August 31).

LECTURER IN CHEMISTRY, with special qualifications in Organic Chemistry—The Secretary, The University, Birmingham 3 (August 31).

RESEARCH ASSISTANTS (6, Grade II) in the Victoria and Albert Museum—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 2716 (August 31).

PRINCIPAL SCIENTIFIC OFFICER and SENIOR SCIENTIFIC OFFICER (preferably with experience in optics and small electrical and mechanical devices) for research and development work on photography from high speed aircraft and on air survey photography, and a SCIENTIFIC OFFICER (preferably having bias to mathematics and knowledge of aerodynamics) for work on automatic pilots and blind landing, at the Royal Aircraft Establishment, Farnborough—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.43/49A (August 31).

LECTURER (MALE) IN DAIRYING, a RESEARCH ASSISTANT IN THE MILK UTILIZATION DEPARTMENT, and a TECHNICAL ASSISTANT IN ANIMAL HUSBANDRY—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 1).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (Electronics), and an ASSISTANT LECTURER IN VETERINARY BACTERIOLOGY—The Registrar, The University, Liverpool (September 3).

LECTURER and an ASSISTANT LECTURER IN THE DEPARTMENT OF MATHEMATICS at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (September 15).

FIRE RESEARCH OFFICER in the New Zealand Department of Scientific and Industrial Research—The Office of the High Commissioner for New Zealand, 415 Strand, London, W.C.2 (September 15).

LECTURER or ASSISTANT LECTURER IN CHEMISTRY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (September 30).

SENIOR LECTURER and LECTURER IN PSYCHOLOGY, and a SENIOR LECTURER and a JUNIOR LECTURER IN PHILOSOPHY, at the Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

PROFESSOR OF PHYSIOLOGY in the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

LECTURER IN ZOOLOGY in the University College of the Gold Coast—The Secretary, Inter-University Council, 8 Park Street, London, W.1 (September 30).

TECHNICIAN IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, University College, Gower Street, London, W.C.1, quoting Physiology/1.

LECTURER IN THE DEPARTMENT OF PHYSICS—The Principal, Technical College, Queen Street South, Huddersfield.

SENIOR LECTURER IN MECHANICAL ENGINEERING, and a LECTURER IN MECHANICAL ENGINEERING—The Clerk and Treasurer, Dundee Technical College, Dundee.

ASSISTANT or ASSOCIATE PROFESSORSHIPS OF BIOCHEMISTRY AND OF GENERAL AND ANALYTICAL CHEMISTRY—The Secretary, Department of Chemistry, University of British Columbia, Vancouver, B.C., Canada.

GLASS BLOWER, with knowledge of vacuum technique, for research in physics—Prof. K. G. Emeleus, Queen's University, Belfast.

PRINCIPAL MEDICAL OFFICER (Research) (bacteriologist with good experience of original research), a PRINCIPAL SCIENTIFIC OFFICER (bacteriologist with good experience of original research), a PRINCIPAL SCIENTIFIC OFFICER (biochemist with good honours degree and good experience of original research with special knowledge of bacterial chemistry), MEDICAL OFFICERS (Research) (bacteriologists or experimental pathologists with experience of original research), SENIOR SCIENTIFIC OFFICERS (bacteriologists with experience of original research), SENIOR SCIENTIFIC OFFICERS (biochemists with good honours degree and research experience in bacterial chemistry), and EXPERIMENTAL OFFICERS (highly skilled in experimental bacteriology), in a Ministry of Supply Research Establishment in Southern England—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2729.

GAS ANALYST—The Assistant Secretary, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

TECHNICIANS (2) to take charge of animals in the Department of Physiology and Biochemistry—The Secretary of the University Court, The University, Glasgow, W.2.

LECTURER IN BIOLOGY (mainly to teach Zoology up to the standard of the Special Degree of London University)—The Registrar, Municipal College, Portsmouth.

LECTURER IN MICROBIOLOGY at the Massey Agricultural College, Palmerston North—The High Commissioner for New Zealand, 415 Strand, London, W.C.2.

RESEARCH ASSISTANT (honours graduate in chemistry) in the Department of Physics, for work on the properties and structure of proteins—The Secretary, University College, Dundee.

HYDRAULICS ENGINEERS (2) in the Public Works Department, Gold Coast—The Director of Recruitment, Colonial Service, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/109.

CHEMIST, for technical analytical post in the Department of Chemistry—The Secretary, Queen's University, Belfast.

DIRECTOR of Research Station and Demonstration Farm—The Secretary, Association of Fish Meal Manufacturers, Halifax House, 86 Cleethorpe Road, Grimsby.

CHIEF ENGINEER (Waterworks Department) in Barbados—The Director of Recruitment, Colonial Service, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27329/25.

LABORATORY ASSISTANT IN THE DEPARTMENT OF PHYSIOLOGY—The Professor of Physiology, The University, Bristol 8.

DIRECTOR of the Bureau of Pastures and Field Crops—The Secretary, Commonwealth Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1.

SOCIAL SCIENTIST (male), to join a team engaged on research on the communication and practical application of industrial sociological developments—The Secretary, Tavistock Institute of Human Relations, 2 Beaumont Street, London, W.1.

CHIEF LABORATORY TECHNICIAN—The Secretary, Stafford Hospital Management Committee, 13 Foregate Street, Stafford.